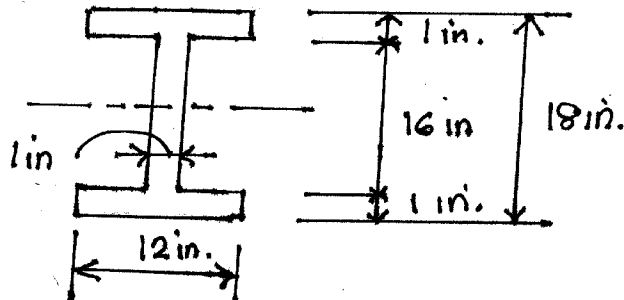


EXCLUSIVE: Just in Edutruth only

CHAPTER 8

PROB #8-1



Elastic calculations

$$A = (2)(12)(1) + (16)(1) = 40 \text{ in.}^2$$

$$I = \left(\frac{1}{12}\right)(12)(18)^3 - \left(\frac{1}{12}\right)(11)(16)^3 = 2077.3 \text{ in.}^4$$

$$S = \frac{2077.3}{9.00} = \boxed{230.8 \text{ in.}^3}$$

$$M_y = F_y S = \frac{(50)(230.8)}{12} = \boxed{962 \text{ ft-k}}$$

Plastic calculations

$$Z = (2)(12)(1)(8.5) + (2)(1)(8)(4) = \boxed{268 \text{ in.}^3}$$

$$M_m = F_y Z = \frac{(50)(268)}{12} = \boxed{1117 \text{ ft-k}}$$

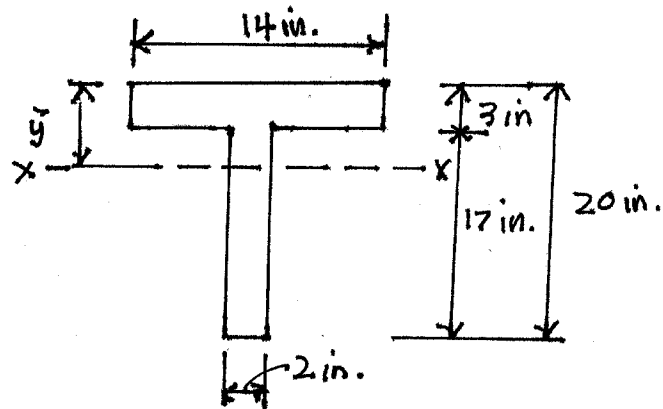
Shape factor

$$S.F. = \frac{268}{230.8} = \boxed{1.16}$$

✓ 962 ft-k

EXCLUSIVE: Just in Edutruth only

PROB #8-2



Elastic calculations

$$\bar{y} = \frac{(14)(3)(1.5) + (17)(2)(11.5)}{(14)(3) + (2)(17)} = 5.97 \text{ in.}$$

$$I_x = \left(\frac{1}{3}\right)(2)(14.03^3 + 2.97^3) + \left(\frac{1}{12}\right)(14)(3)^3 + (14)(3)(4.47)^2$$

$$= 2729.3 \text{ in.}^4$$

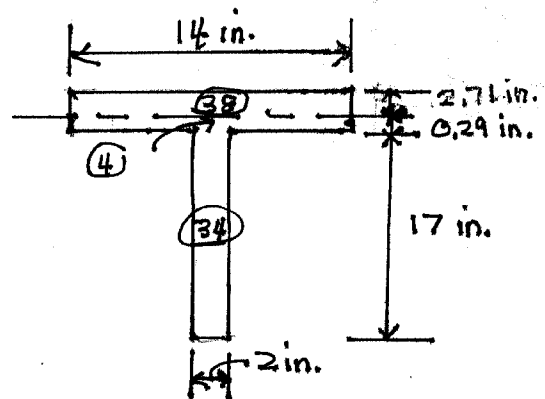
$$S_x = \frac{2729.3}{14.03} = \boxed{194.53 \text{ in.}^3}$$

Plastic calculations

$$Z = (38)\left(\frac{2.71}{2}\right) + (4)\left(\frac{0.29}{2}\right)$$

$$+ (34)(9.79)$$

$$= \boxed{350.93 \text{ in.}^3}$$



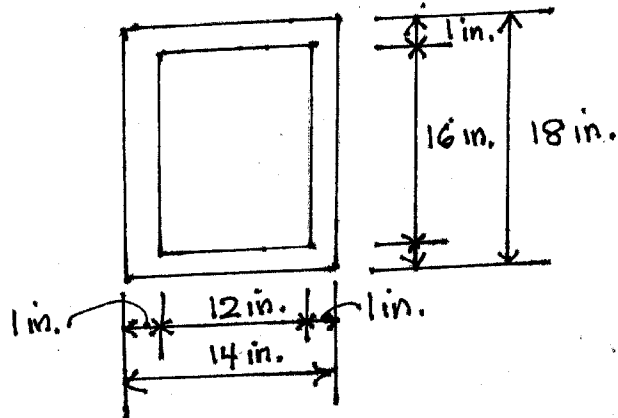
Shape factor

$$S.F. = \frac{350.93}{194.53} = \boxed{1.80}$$

✓ gcm

EXCLUSIVE: Just in Edutruth only

PROB # 8-3



Elastic calculations

$$I_x = \left(\frac{1}{12}\right)(14)(18)^3 - \left(\frac{1}{12}\right)(12)(16)^3 = 2708 \text{ in.}^4$$

$$S = \frac{2708}{9.00} = \boxed{300.9 \text{ in.}^3}$$

$$M_y = \frac{(50)(300.9)}{12} = 1254 \text{ ft-k}$$

plastic calculations

$$Z = (4)(1)(8)(4) + (2)(14)(1)(8.5) = 366 \text{ in}^3$$

$$M_m = \frac{(50)(366)}{12} = \boxed{1525 \text{ ft-lb}}$$

Shape factor

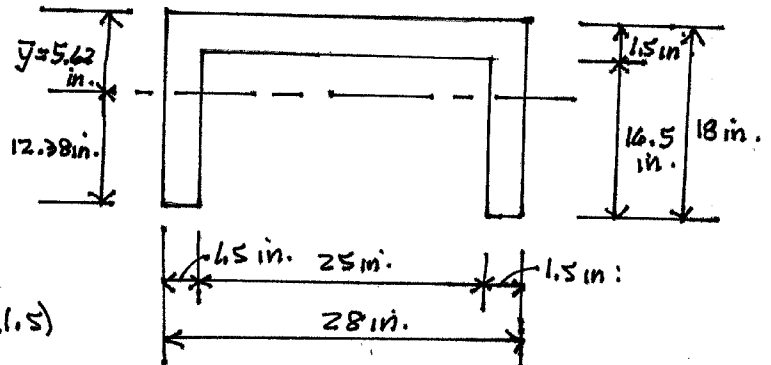
$$S.F. = \frac{366}{300.9} = 1.22$$

$$v_{gcm} \equiv$$

EXCLUSIVE: Just in Edutruth only

PROB# 8-4

Elastic calculations



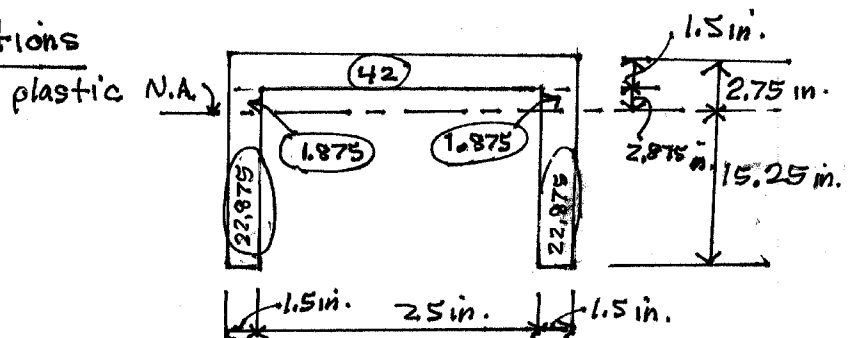
$$A = (28)(1.5) + (2)(16.5)(1.5) = 91.5 \text{ in.}^2$$

$$\bar{y} = \frac{(28)(1.5)(0.75) + (2)(16.5)(1.5)(1.5 + 8.25)}{91.5} = 5.62 \text{ in.}$$

$$I_x = \left(\frac{1}{3}\right)(28)(1.5)(5.62^3 + 12.38^3) + \left(\frac{1}{3}\right)(25)(1.5)^3 + (25)(1.5)\left(5.62 - \frac{1.5}{2}\right)^2 = 2971.3 \text{ in.}^3$$

$$S_x = \frac{2971.3}{12.38} = \boxed{240.0 \text{ in.}^3}$$

Plastic calculations



$$Z_x = (2)(22.875)\left(\frac{15.25}{2}\right) + (2)(1.875)\left(\frac{1.25}{2}\right) + (42)\left(1.25 + \frac{1.5}{2}\right) = 435.2 \text{ in.}^3$$

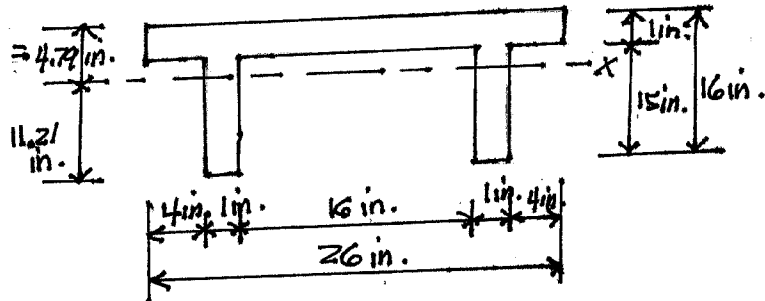
Shape Factor

$$S.F. = \frac{435.2}{240.0} = \boxed{1.81}$$

✓ gcm

EXCLUSIVE: Just in Edutruth only

PROB # 8-5



Elastic calculations

$$A = (26)(1) + (2)(15)(1) = 56 \text{ in.}^2$$

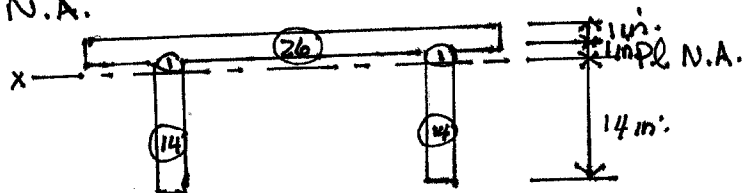
$$\bar{y} = \frac{(26)(0.5) + (2)(15)(1 + \frac{15}{2})}{56} = 4.79 \text{ in.}$$

$$I_x = (2)(\frac{1}{3})(1)(11.21^3 + 3.79^3) + (\frac{1}{12})(26)(1)^3 + (26)(4.79)^2 = 1456.1 \text{ in.}^4$$

$$S_x = \frac{1456.1}{11.21} = \boxed{129.9 \text{ in.}^3}$$

Plastic calculations

Locating N.A.



$$Z = (2)(1)(0.50) + (26)(1.5) + (2)(14)(7) = \boxed{236 \text{ in.}^3}$$

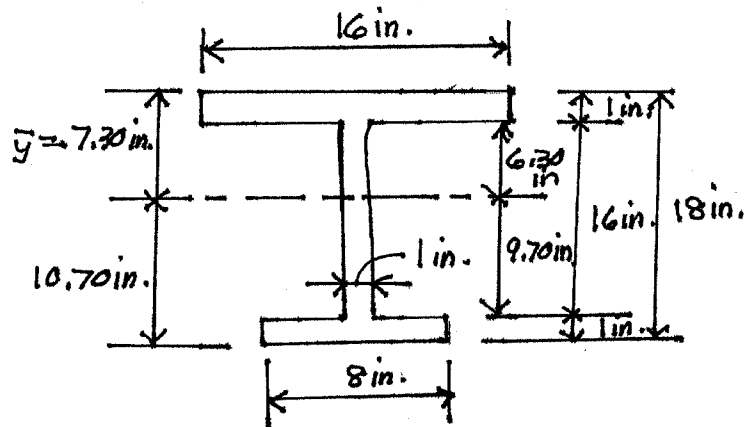
Shape Factor

$$S.F. = \frac{236}{129.9} = \boxed{1.82}$$

✓ gcm

EXCLUSIVE: Just in Edutruth only

PROB # 8-6



Elastic calculations

$$A = (16)(1) + (16)(1) + (8)(1) = 40 \text{ in.}^2$$

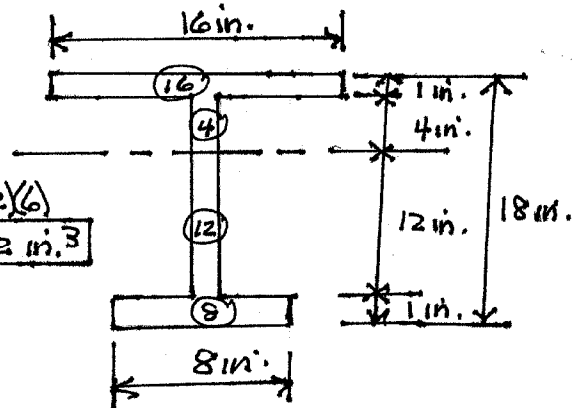
$$\bar{y} = \frac{(16)(\frac{1}{2}) + (16)(1+8) + (8)(18-\frac{1}{2})}{40} = 7.30 \text{ in.}$$

$$I_x = \left(\frac{1}{3}\right)(1)(6.30^3 + 9.70^3) + \left(\frac{1}{3}\right)(16)(1)^3 + (16)(6.80)^2 + \left(\frac{1}{3}\right)(8)(1)^3 + (8)(10.20)^2 = 1961 \text{ in.}^4$$

$$S_x = \frac{1961}{10.70} = \boxed{183.3 \text{ in.}^3}$$

Plastic calculations

$$Z_x = (16)(4.5) + (4)(2) + (12)(6) + (8)(12.5) = \boxed{252 \text{ in.}^3}$$



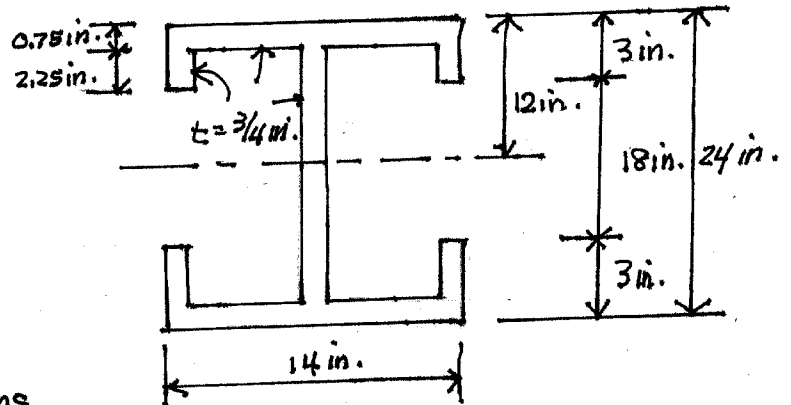
Shape Factor

$$S.F. = \frac{252}{183.3} = \boxed{1.37}$$

✓ gcm

EXCLUSIVE: Just in Edutruth only

PROB # 8-7



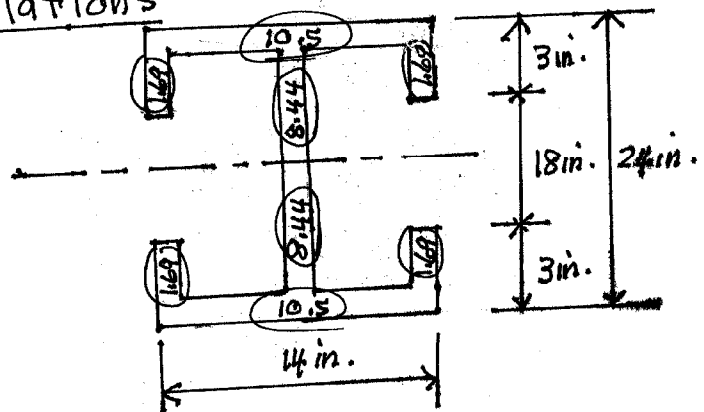
Elastic calculations

$$A = (2)(14)\left(\frac{3}{4}\right) + (4)(2.25)\left(\frac{3}{4}\right) + (24 - 2 \times \frac{3}{4})\left(\frac{3}{4}\right) = 44.625 \text{ in.}^2$$

$$I_x = \left(\frac{1}{12}\right)\left(\frac{3}{4}\right)(22.5)^3 + 2\left(\frac{1}{12}\right)(4)\left(\frac{3}{4}\right)^3 + 2\left(\frac{3}{4} \times 14\right)(11.625)^2 + \left(\frac{1}{12}\right)(4)\left(\frac{3}{4}\right)(2.5)^3 + (4)\left(\frac{3}{4} \times 2.25\right)(10.125)^2 = 4246 \text{ in.}^4$$

$$S = \frac{4246}{12} = \boxed{353.8 \text{ in.}^3}$$

Plastic calculations



$$Z = (2)(8.44)\left(\frac{11.25}{2}\right) + (2)(10.5)\left(12 - \frac{0.75}{2}\right) + (4)(1.69)\left(11.25 - \frac{2.25}{2}\right) = \boxed{407.4 \text{ in.}^3}$$

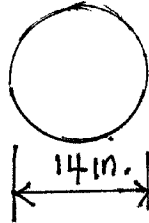
Shape Factor

$$S.F. = \frac{407.4}{353.8} = \boxed{1.15}$$

$r_{gc} = m_c$

EXCLUSIVE: Just in Edutruth only

PROB # 8-8



Elastic calculations

$$A = \frac{\pi d^2}{4} = \frac{(\pi)(14)^2}{4} = 153.9 \text{ in.}^2$$

$$I = \frac{\pi d^4}{64} = \frac{(\pi)(14)^4}{64} = 1885.7 \text{ in.}^4$$

$$S = \frac{I}{c} = \frac{1885.7}{7.00} = \boxed{269.4 \text{ in.}^3}$$

$$M_y = F_y S = \frac{(50)(269.4)}{12} = \boxed{1122.5 \text{ ft-k}}$$

Plastic calculations

$$\frac{1}{2}A = \frac{1}{2} \times 153.9 = 76.95 \text{ in.}^2 \quad (Z = (76.95)(0.42413)(7)(2) = 457.3)$$

$$Z = \frac{d^3}{6} = \frac{(14)^3}{6} = \boxed{457.3 \text{ in.}^3}$$

$$M_m = F_y Z = \frac{(50)(457.3)}{12} = \boxed{1905.4 \text{ ft-k}}$$

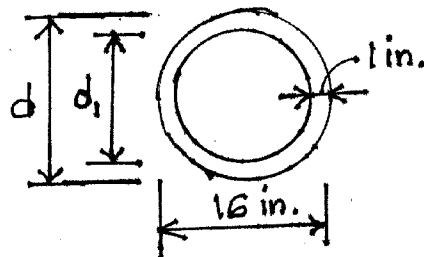
Shape factor

$$S.F. = \frac{457.3}{269.4} = \boxed{1.70}$$

✓ $g < m \equiv$

EXCLUSIVE: Just in Edutruth only

PROB #8-9



Elastic calculations

$$A = \frac{(\pi \times 16)^2}{4} - \frac{(\pi \times 14)^2}{4} = 201.1 \text{ in.}^2$$

$$I = \frac{(\pi \times 16)^4}{64} - \frac{(\pi \times 14)^4}{64} = 1331.3 \text{ in.}^4$$

$$S = \frac{1331.3}{8.00} = \boxed{166.4 \text{ in.}^3}$$

Plastic calculations

$$Z = \frac{d^3}{6} - \frac{d_i^3}{6} = \frac{(16)^3}{6} - \frac{(14)^3}{6} = \boxed{225.3 \text{ in.}^3}$$

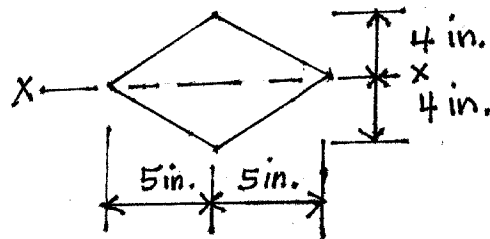
Shape Factor

$$S.F. = \frac{225.3}{166.3} = \boxed{1.35}$$

VGCME

EXCLUSIVE: Just in Edutruth only

PROB # 8-10



Elastic calculations

$$A = \left(\frac{1}{2}\right)(10)(4)(2) = 40 \text{ in.}^2$$

$$I = 2 \left[\frac{(40)(4)^3}{12} \right] = 106.7 \text{ in.}^4$$

$$S = \frac{106.7}{4} = \boxed{26.67 \text{ in.}^3}$$

Plastic calculations

$$Z = \left(\frac{1}{2}\right)(10)(4)(2)\left(\frac{4}{3}\right) = \boxed{53.33 \text{ in.}^3}$$

Shape Factor

$$S.F. = \frac{53.33}{26.67} = \boxed{2.00}$$

✓ gcm

EXCLUSIVE: Just in Edutruth only

PROB #8-11

Using a W27x146 ($d=27.4$ in., $b_f=14.0$ in., $t_f=0.875$ in.,
 $t_w=0.605$ in.)

Elastic calculations

$$I = \left(\frac{1}{12}\right)(14.0)(27.4)^3 - \left(\frac{1}{12}\right)(13.345)(25.45)^3$$

$$= 5599 \text{ in.}^4$$

$$S = \frac{5599}{13.70} = \boxed{408.7 \text{ in.}^3}$$

Plastic calculations

$$Z = (14.0)(13.70)\left(\frac{13.70}{2}\right)(2) - (13.345)(12.725)\left(\frac{12.725}{2}\right)$$

$$= \boxed{458.6 \text{ in.}^3}$$

Shape factor

$$S.F. = \frac{458.6}{408.7} = \boxed{1.12}$$

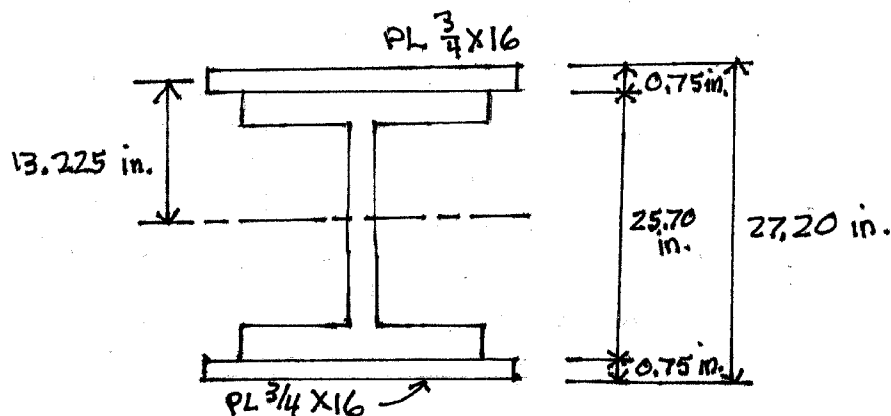
$V < M^c$

EXCLUSIVE: Just in Edutruth only

PROB # 8-12

Using a W24 x 207 ($d = 25.7$ in., $t_w = 0.870$ in.,

$t_f = 1.57$ in., I_x of W = 6820 in.⁴, Z_x of W = 606 in.³)



Elastic calculations

$$I_x = 6820 + (2)\left(\frac{3}{4} \times 16\right)(13.225)^2 = 11,018 \text{ in.}^4$$

$$S_x = \frac{11,018}{13.60} = \boxed{810.1 \text{ in.}^3}$$

Plastic calculations

$$Z_x = 606 + (2)\left(\frac{3}{4} \times 16\right)(13.225) = \boxed{923.4 \text{ in.}^3}$$

Shape factor

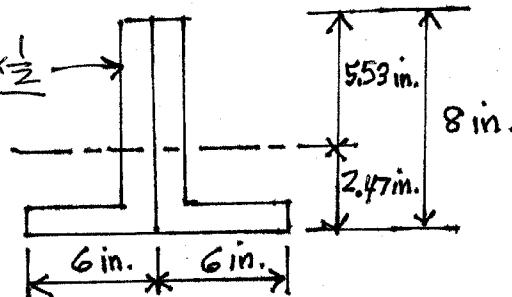
$$S.F. = \frac{923.4}{810.1} = \boxed{1.14}$$

✓ gcm

EXCLUSIVE: Just in Edutruth only

PROB # 8-13

Using 2 Ls 8x6x $\frac{1}{2}$
(long legs b. to b.)

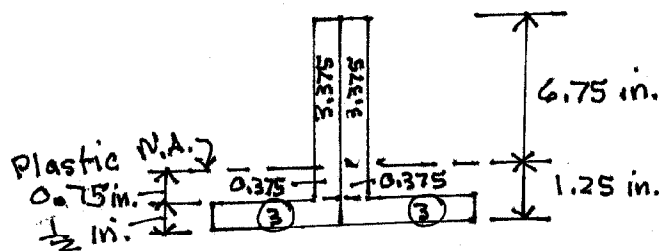


Elastic calculations

$$I_x = \left(\frac{1}{3}\right)(1)(5.53^3 + 2.47^3) + (1)\left(\frac{1}{2}\right)(2.22)^2 = 88.61 \text{ in.}^4$$

$$S_x = \frac{88.61}{5.59} = \boxed{16.02 \text{ in.}^3}$$

Plastic calculations



$$Z = (2)(3.375)\left(\frac{6.75}{2}\right) + (2)(0.375)\left(\frac{0.75}{2}\right) + (2)(3)(1.00) = \boxed{29.06 \text{ in.}^3}$$

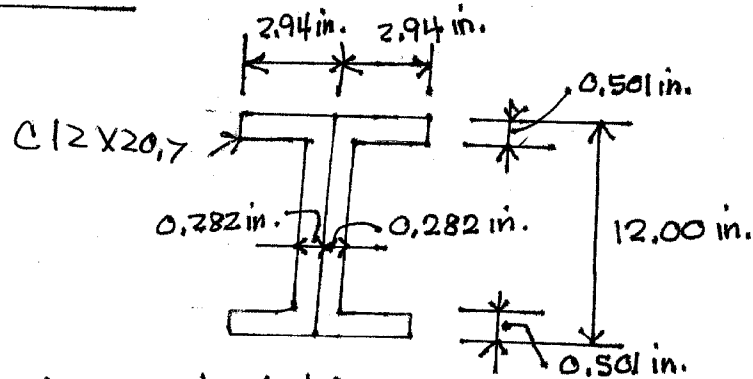
Shape factor

$$S.F. = \frac{29.06}{16.02} = \boxed{1.81}$$

✓ gmc

EXCLUSIVE: Just in Edutruth only

PROB #8-14



Elastic calculations

$$I_x = \left(\frac{1}{12}\right)(5.88)(12)^3 - \left(\frac{1}{12}\right)(5.316)(10.998)^3 = 257.4 \text{ in.}^4$$

$$S = \frac{257.4}{6} = \boxed{42.9 \text{ in.}^3}$$

Plastic calculations

$$Z = (2)(6.00)(5.88)(3.00) - (4)(2.658)(5.499)\left(\frac{5.499}{2}\right) = \boxed{50.92 \text{ in.}^3}$$

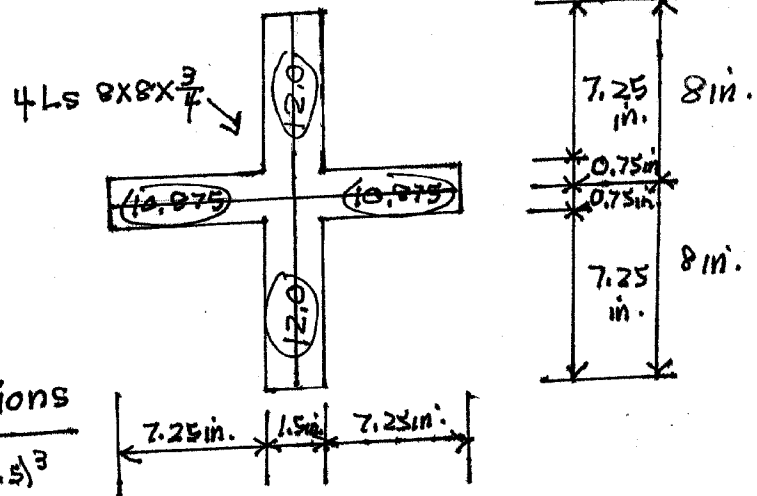
Shape factor

$$S.F. = \frac{50.92}{42.19} = \boxed{1.19}$$

✓ gcm

EXCLUSIVE: Just in Edutruth only

PROB #8-15



Elastic calculations

$$I_x = \left(\frac{1}{12}\right)(14.50)(1.5)^3 + \left(\frac{1}{12}\right)(1.5)(16)^3 = 516 \text{ in.}^4$$

$$S_x = \frac{516}{8.00} = \boxed{64.5 \text{ in.}^3}$$

Plastic calculations (using areas shown on figure)

$$Z_x = (2)(12.0)(4.00) + (2)(10.875)\left(\frac{0.75}{2}\right) = \boxed{104.16 \text{ in.}^3}$$

Shape factor

$$S.F. = \frac{104.16}{64.5} = \boxed{1.61}$$

✓ 8 < 1.61

EXCLUSIVE: Just in Edutruth only

PROB #8-16

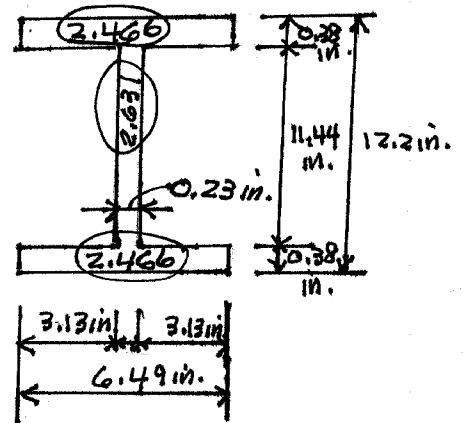
Using a W 12 x 26 (d = 12.2 in., $t_w = 0.230$ in.,
 $b_f = 6.49$ in., $t_f = 0.380$ in.)

Elastic calculations

$$I_x = \left(\frac{1}{12}\right)(6.49)(12.2)^3 - \left(\frac{1}{12}\right)(2 \times 3.13)(11.44)^3$$

$$= 201.0 \text{ in.}^4$$

$$S_x = \frac{201.0}{6.1} = \boxed{32.95 \text{ in.}^3}$$



Plastic calculations

Referring to sketch of shape areas of the parts are shown

$$Z_x = (2)(2.466)\left(6.1 - \frac{0.38}{2}\right) + (2)\left(\frac{2.631}{2}\right)\left(\frac{11.44}{4}\right)$$

$$= \boxed{36.67 \text{ in.}^3}$$

Shape factor

$$S.F. = \frac{36.67}{32.95} = \boxed{1.11}$$

Notice AISC Table 1-1 values are slightly different as they account for exact shape (i.e. fillets) of section

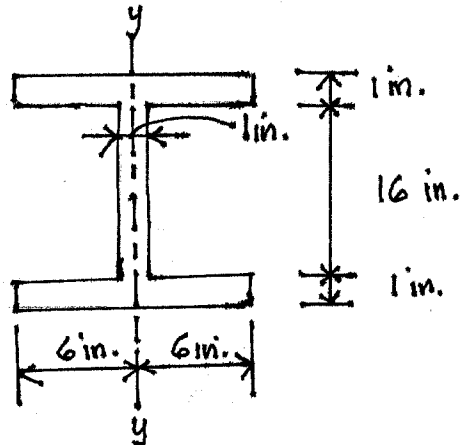
$$\left[I_x = 204 \text{ in.}^4, S_x = 33.4 \text{ in.}^3, Z_x = 37.2 \text{ in.}^3, \right.$$

$$\left. S.F. = \frac{37.2}{33.4} = \boxed{1.11} \right]$$

✓ gem

EXCLUSIVE: Just in Edutruth only

PROB # 8-17



Elastic calculations

$$I_y = \left(\frac{1}{12}\right)(1)(12)^3(2) + \left(\frac{1}{12}\right)(16)(1)^3 = 289.93 \text{ in.}^4$$

$$S_y = \frac{289.93}{6.00} = \boxed{48.22 \text{ in.}^3}$$

Plastic calculations

$$Z_y = (4)(6)(1)(3) + (2)(16)\left(\frac{1}{2}\right)\left(\frac{1}{4}\right) = \boxed{76 \text{ in.}^3}$$

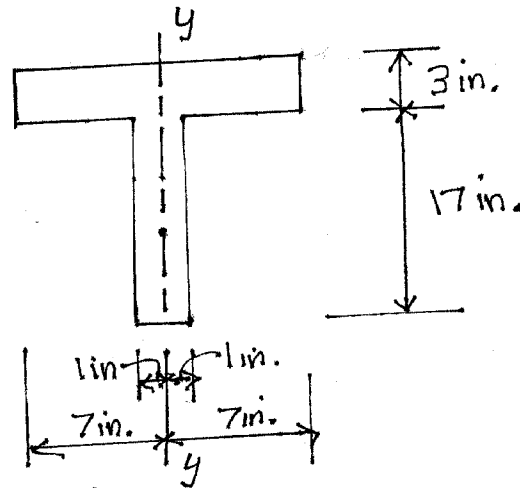
Shape factor

$$S.F. = \frac{76}{48.22} = \boxed{1.58}$$

✓ gcm

EXCLUSIVE: Just in Edutruth only

PROB# 8-18



Elastic calculations

$$I_y = (2) \left[\left(\frac{1}{3} \right) (3) (7)^3 \right] + \left(\frac{1}{12} \right) (17) (1)^3 = 697.3 \text{ in.}^4$$

$$S_y = \frac{697.3}{7} = \boxed{99.62 \text{ in.}^3}$$

Plastic calculations

$$Z_y = 2 \left[(3) (7) (3.5) + (17) (1) \left(\frac{1}{2} \right) \right] = \boxed{164 \text{ in.}^3}$$

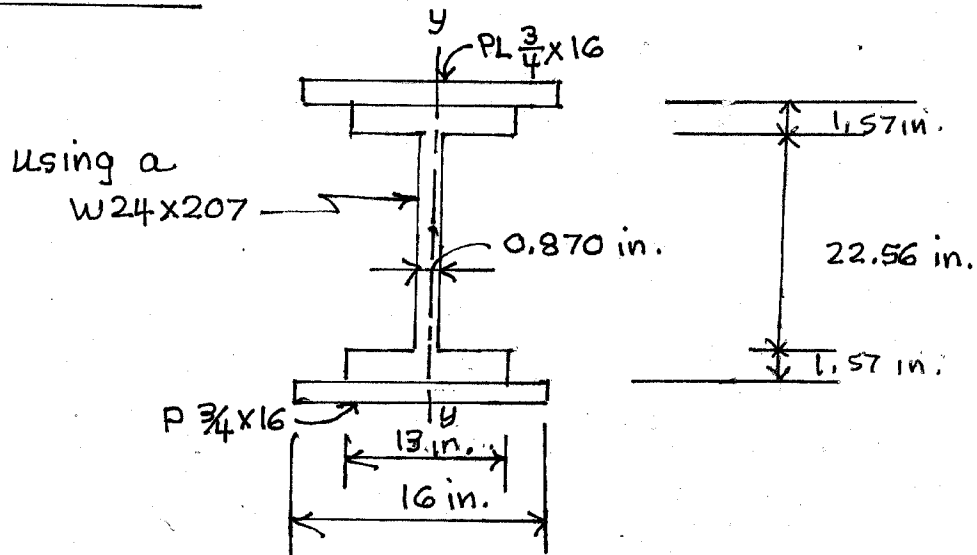
Shape factor

$$S.F. = \frac{164}{99.62} = \boxed{1.65}$$

$\checkmark \text{ gcm} \equiv$

EXCLUSIVE: Just in Edutruth only

PROB # 8-19



Elastic calculations

$$I_y = (2) \left(\frac{1}{12} \right) \left(\frac{3}{4} \right) (16)^3 + (2) \left(\frac{1}{12} \right) (1.57) (13)^3 + \left(\frac{1}{12} \right) (22.56) (0.87)^3 = 1088 \text{ in.}^4$$

$$S_y = \frac{1088}{8.00} = \boxed{136 \text{ in.}^3}$$

Plastic calculations

$$Z_y = (4) \left(\frac{3}{4} \right) (8) (4) + (4) (6.5) (1.57) \left(\frac{6.5}{2} \right) + (2) (22.56) (0.435) \left(\frac{0.435}{2} \right) = \boxed{232.9 \text{ in.}^3}$$

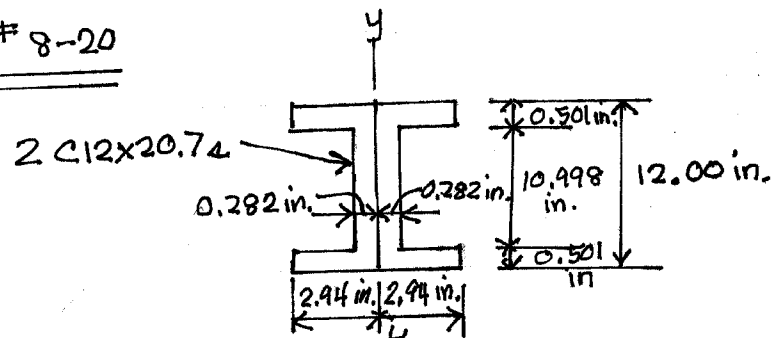
Shape calculations

$$S.F. = \frac{232.9}{136} = \boxed{1.71}$$

✓ JCM

EXCLUSIVE: Just in Edutruth only

PROB # 8-20



Elastic calculations

$$I_y = (2) \left(\frac{1}{12} (0.501) (5.88)^3 \right) + \left(\frac{1}{12} (10.998) (0.564)^3 \right) = 17.1 \text{ in.}^4$$

$$S = \frac{17.1}{2.94} = \boxed{5.82 \text{ in.}^3}$$

Plastic calculations

$$Z_y = (4) (2.94 \times 0.501) \left(\frac{2.94}{2} \right) + (2) (10.998) (0.282) \left(\frac{0.282}{2} \right)$$

$$= \boxed{9.59 \text{ in.}^3}$$

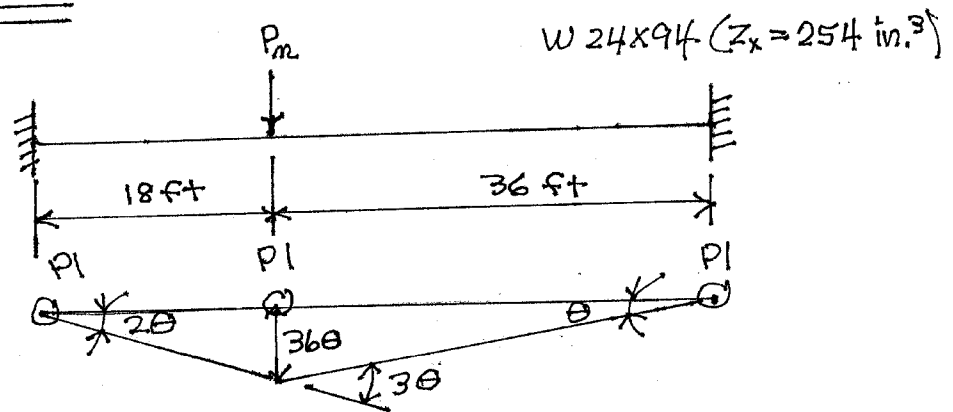
Shape factor

$$S.F. = \frac{9.59}{5.82} = \boxed{1.64}$$

✓ gcm

EXCLUSIVE: Just in Edutruth only <http://edutruth.4shared.com>

PROB # 8-21



$$(P_m)(36\theta) = M_m(6\theta)$$

$$P_m = \frac{M_m}{6}$$

using a W24x94

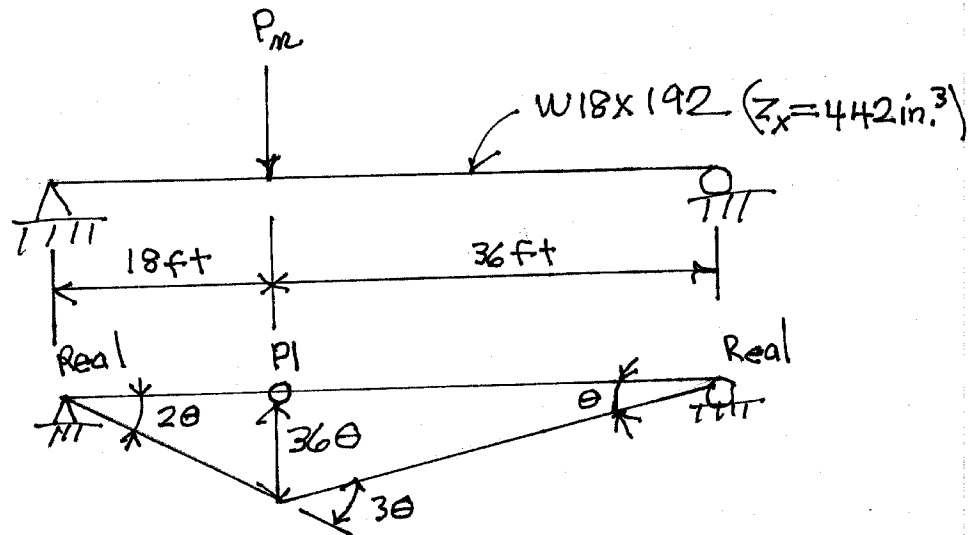
$$M_m = F_y Z = \frac{(50)(254)}{12} = 1058.3 \text{ ft-lb}$$

$$P_m = \frac{1058.3}{6} = \boxed{176.4 \text{ R}}$$

$$v \propto \frac{1}{m^2}$$

EXCLUSIVE: Just in Edutruth only

PROB # 8-22



$$(P_m)(36\theta) = M_m(3\theta)$$

$$P_m = \frac{M_m}{12}$$

Using a W18x192

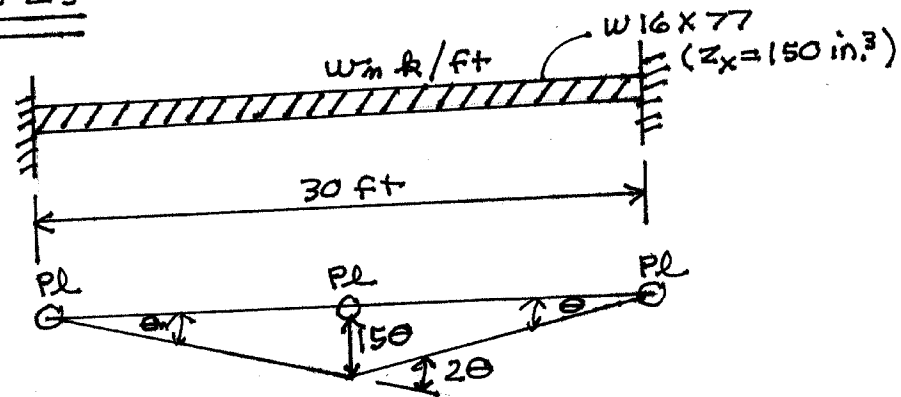
$$M_m = \frac{(50)(442)}{12} = 1841.7 \text{ Ft-k}$$

$$P_m = \frac{1841.7}{12} = \boxed{153.5 \text{ k}}$$

✓ $\theta < \theta_c$

EXCLUSIVE: Just in Edutruth only

PROB # 8-23



$$(30w_m) \left(\frac{1}{2} \times 150 \right) = M_m (4\theta)$$

$$w_m = \frac{4M_m}{225}$$

using a $W16x77$ ($Z_x = 150 \text{ in}^3$)

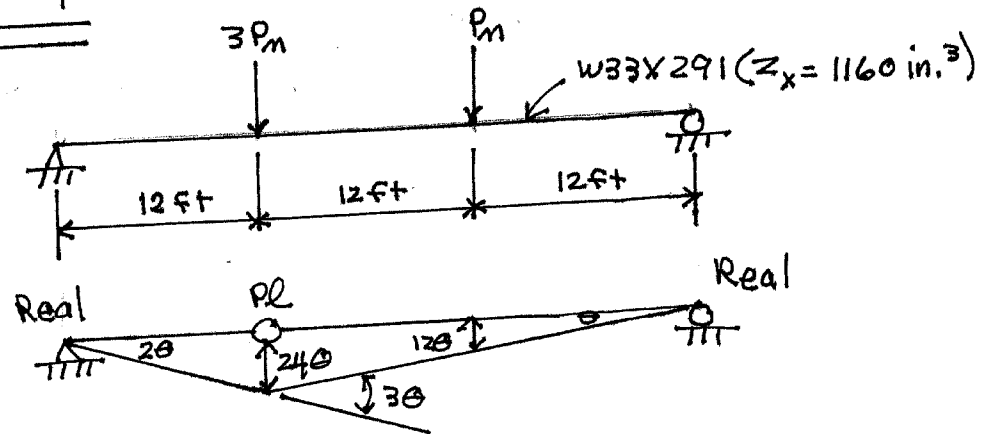
$$M_m = F_y Z = \frac{(50)(150)}{12} = 625 \text{ ft-k}$$

$$w_m = \frac{(4)(625)}{225} = \boxed{11.11 \text{ k/ft}}$$

✓ gcm

EXCLUSIVE: Just in Edutruth only

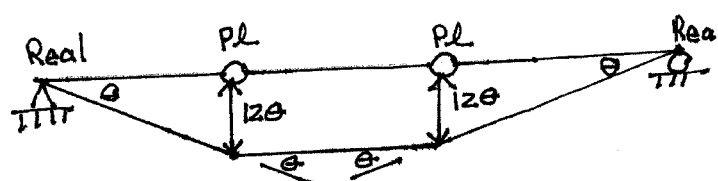
PROB # 8-24



$$\begin{aligned} (3P_m)(24\theta) + (P_m)(12\theta) &= (M_m)(3\theta) \\ (84 P_m \theta) &= (M_m)(3\theta) \\ P_m &= \frac{3M_m}{84} \end{aligned}$$



$$\begin{aligned} (3P_m)(12\theta) + (P_m)(24\theta) &= (M_m)(3\theta) \\ P_m &= \frac{M_m}{20} \end{aligned}$$



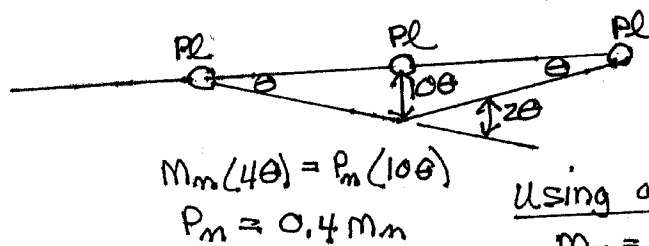
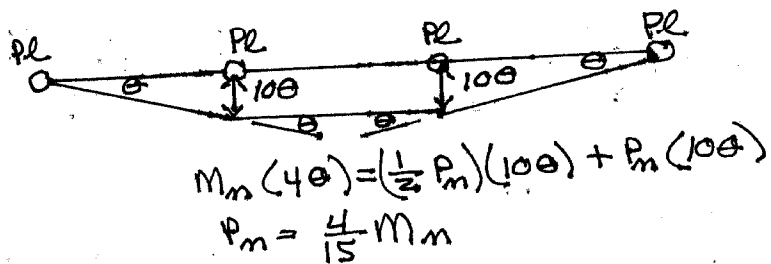
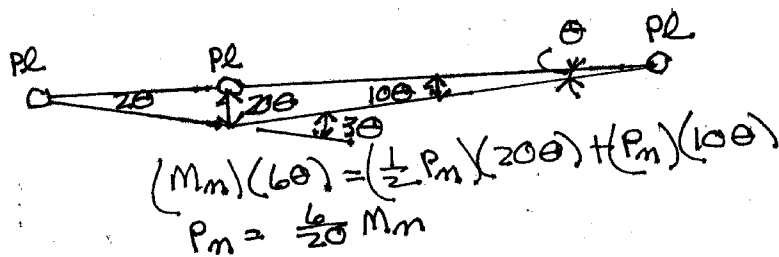
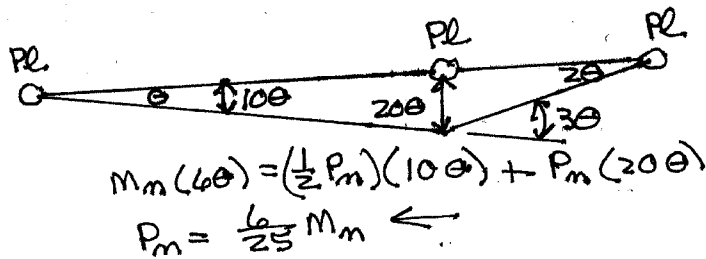
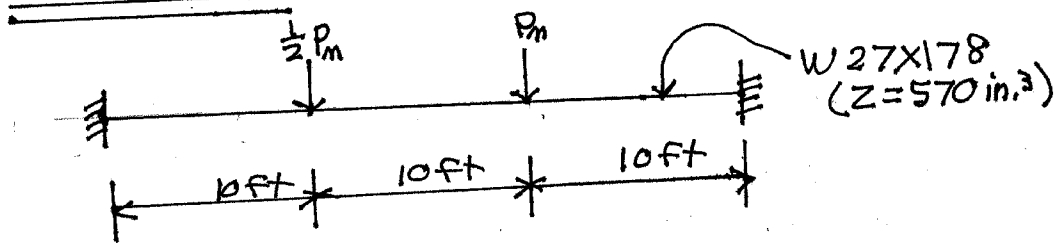
$$\begin{aligned} 3P_m(12\theta) + (P_m)(12\theta) &= M_m(2\theta) \\ P_m &= \frac{M_m}{24} \end{aligned}$$

using a W33 X 291

$$P_m = \frac{(3)(50 \times 1160)}{(84 \times 12)} = \boxed{172.6 \text{ k}}$$

EXCLUSIVE: Just in Edutruth only

PROB # 8-25



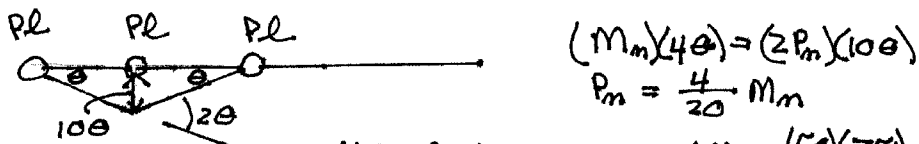
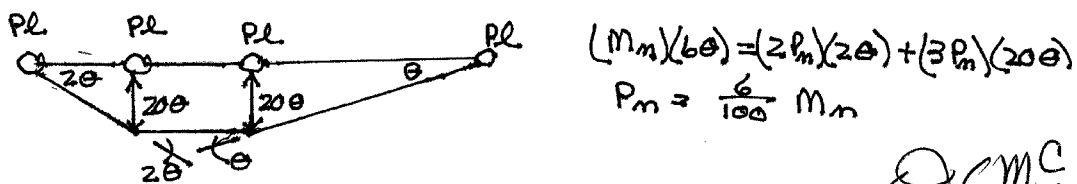
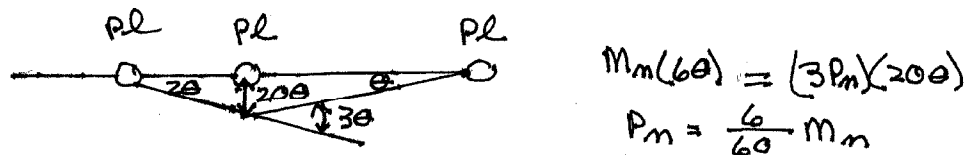
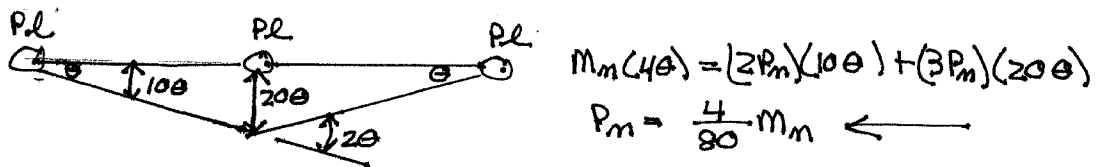
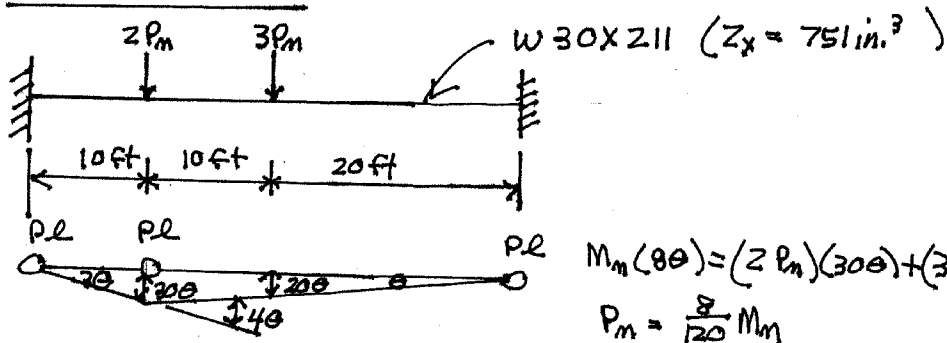
Using a W 27x178

$$m_m = F_y Z = \frac{(50 \times 570)}{12} = 2375 \text{ ft-lb}$$

$$P_m = \frac{6}{25} M_m = \left(\frac{6}{25}\right)(2375) = \boxed{570 \text{ k}}$$

EXCLUSIVE: Just in Edutruth only

PROB# 8-26



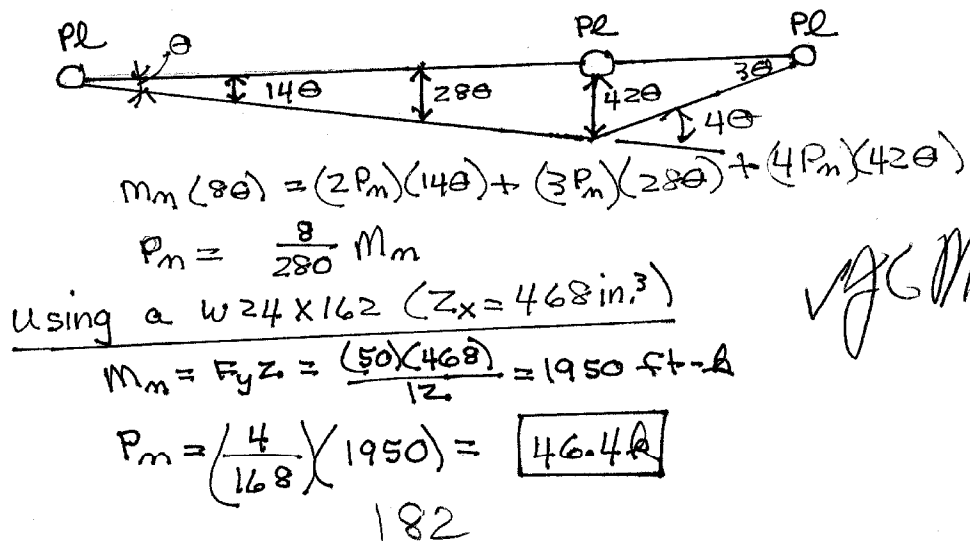
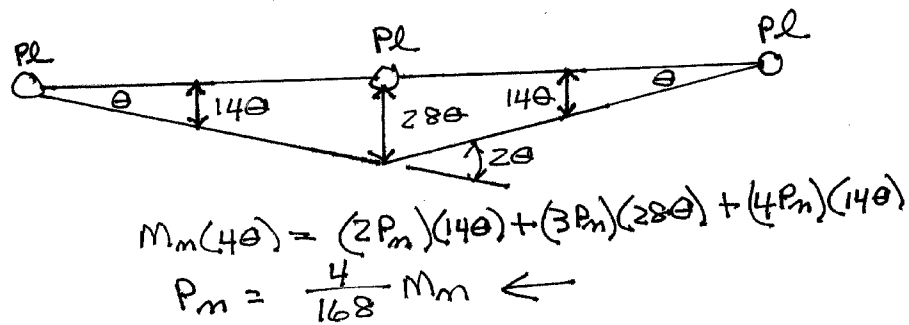
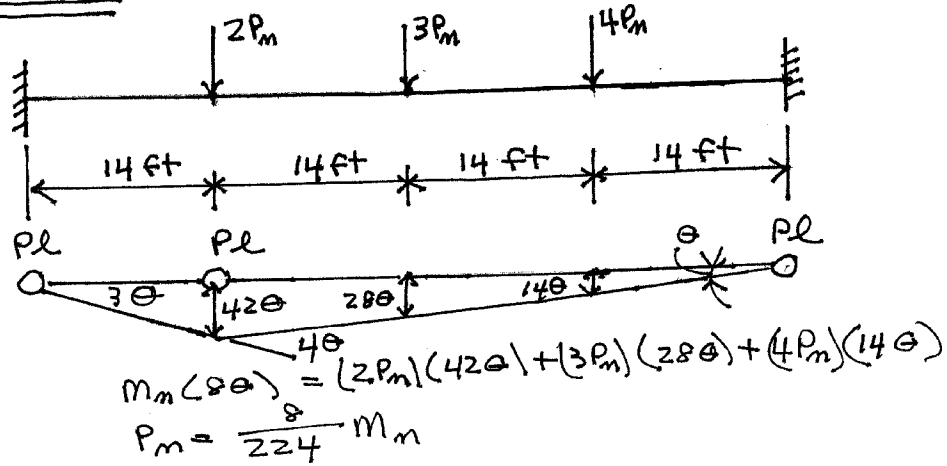
USING A W 30X211 $M_m = \frac{(50 \times 751)}{12} = 3129 \text{ ft-k}$

$P_m = \frac{4}{80} M_m = \left(\frac{4}{80}\right)(3129) = \boxed{156.4 \text{ k}}$

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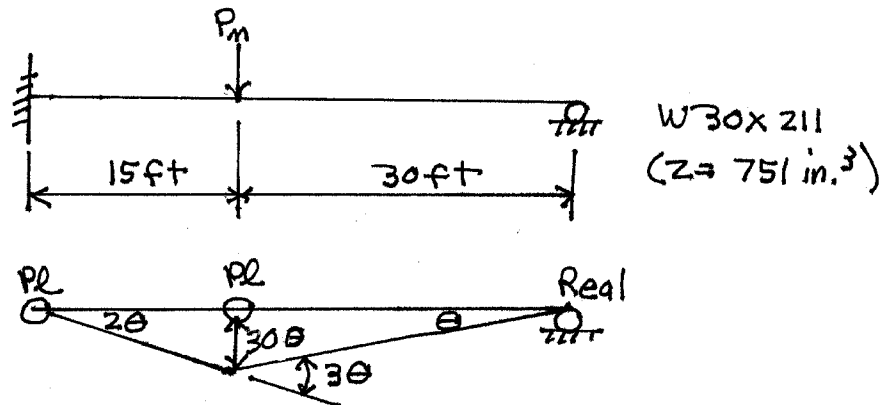
EXCLUSIVE: Just in Edutruth only

PROB # 8-27



EXCLUSIVE: Just in Edutruth only

PROB # 8-28



$$M_m(5\theta) = (P_m)(30\theta)$$

$$P_m = \frac{1}{6} M_m$$

using a W30x211

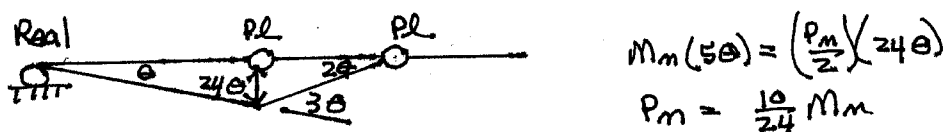
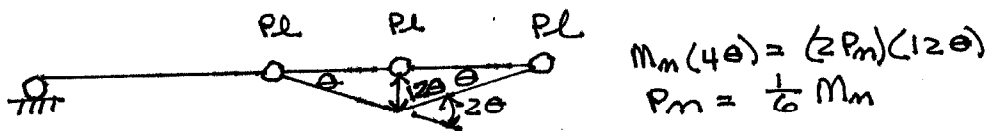
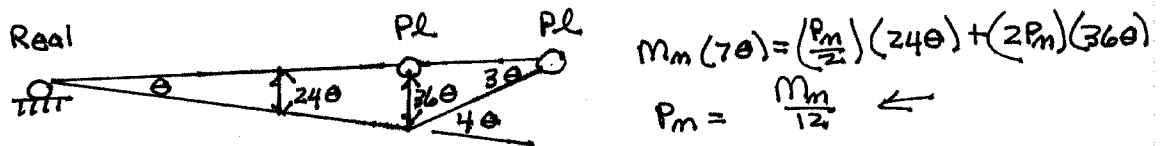
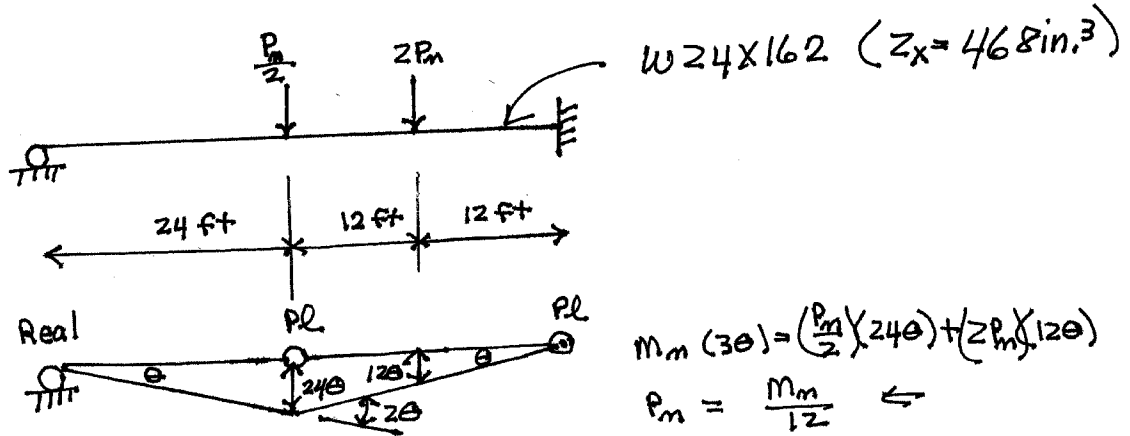
$$M_m = F_y Z = \frac{(50)(751)}{12} = 3129.2 \text{ ft-k}$$

$$P_m = \left(\frac{1}{6}\right)(3129.2) = \boxed{521.5 \text{ k}}$$

$\checkmark \text{ } < M \text{ } \checkmark$

EXCLUSIVE: Just in Edutruth only

PROB # 8-29



$$M_m = F_y Z = \frac{(50)(468)}{12} = 1950 \text{ ft-lb}$$

$$P_m = \frac{1}{12} P_m = \left(\frac{1}{12}\right)(1950) = \boxed{162.5 \text{ k}}$$

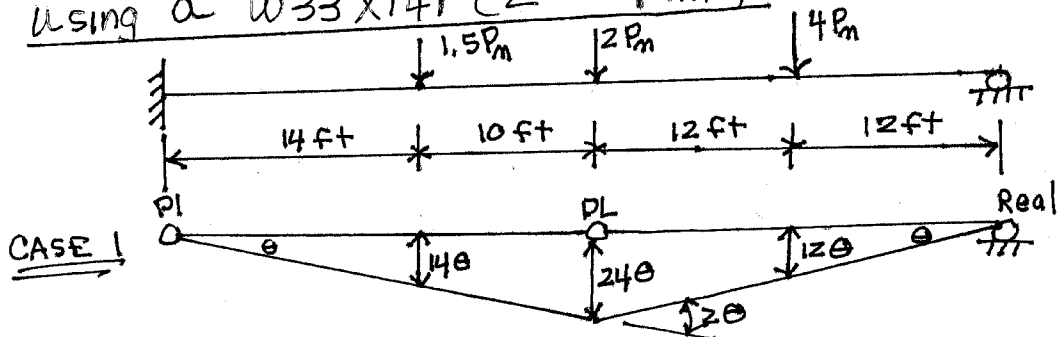
184

✓ JCM

EXCLUSIVE: Just in Edutruth only

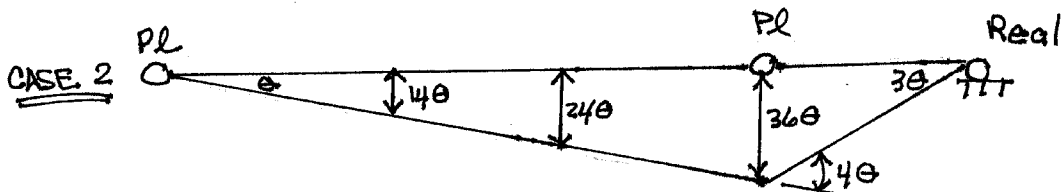
PROB #8-30

using a W33 X141 ($Z = 514 \text{ in}^3$)



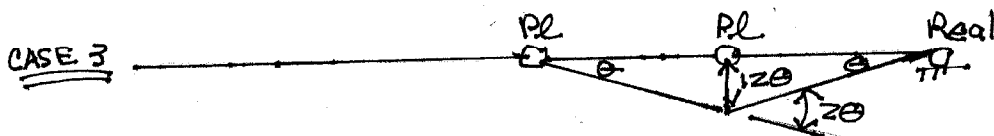
$$M_m(3\theta) = (1.5P_m)(14\theta) + (2P_m)(24\theta) + (4P_m)(12\theta)$$

$$P_m = \frac{M_m}{39}$$



$$M_m(5\theta) = (1.5P_m)(14\theta) + (2P_m)(24\theta) + (4P_m)(36\theta)$$

$$P_m = \frac{5}{213} M_m \leftarrow$$



$$M_m(3\theta) = (4P_m)(12\theta)$$

$$P_m = \frac{M_m}{16}$$

Not all possible mechanisms shown.

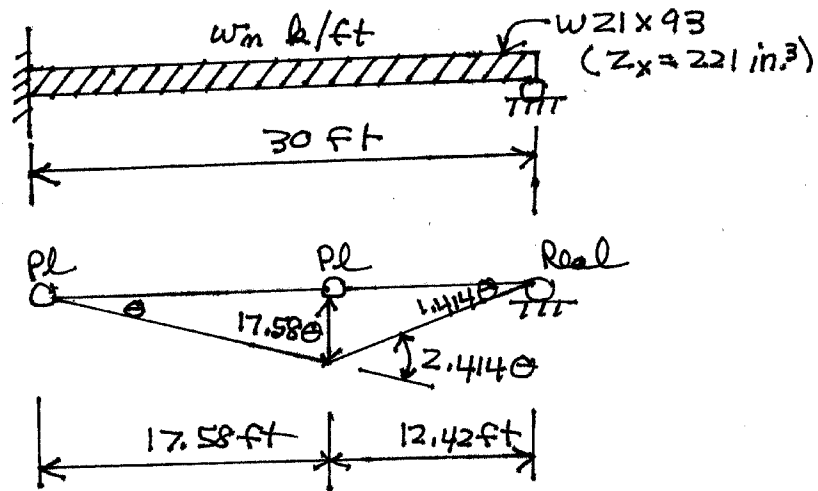
$$M_m = \frac{(50)(514)}{12} = 2141.7 \text{ ft-k}$$

$$P_m = \left(\frac{5}{213}\right)(2141.7) = \boxed{50.27 \text{ k}}$$

✓ g c m e

EXCLUSIVE: Just in Edutruth only

PROB # 8-31



$$M_m (\theta + 2.414\theta) = \left(\frac{1}{2}w_m\right)(30)(17.58\theta)$$

$$M_m = 77.24 w_m$$

$$w_m = \frac{M_m}{77.24}$$

Using a W21x93

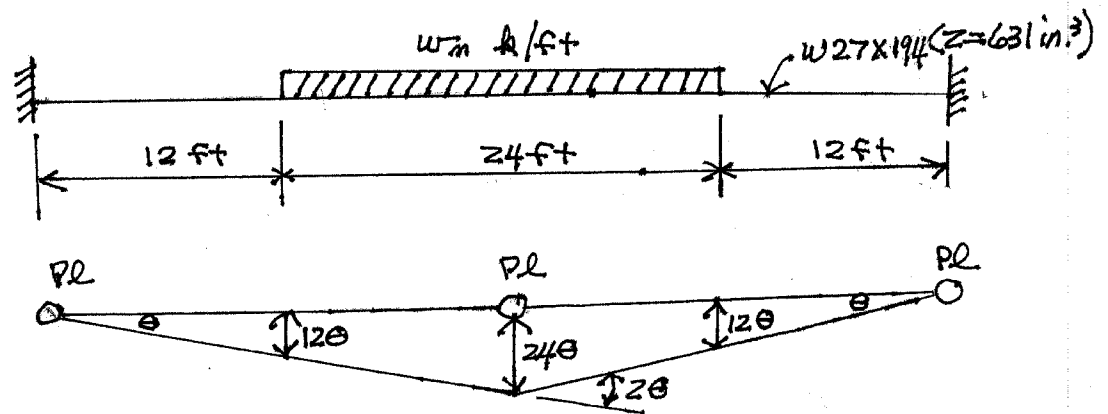
$$M_m = F_y Z = \frac{(50)(221)}{12} = 920.8 \text{ ft-k}$$

$$w_m = \frac{M_m}{77.24} = \frac{920.8}{77.24} = \boxed{11.92 \text{ k/ft}}$$

✓ gcm

EXCLUSIVE: Just in Edutruth only

PROB # 8-32



$$M_m(4\theta) = (24 w_m) \left(\frac{24\theta + 12\theta}{2} \right)$$

$$M_m = 108 w_m$$

using a W27x194

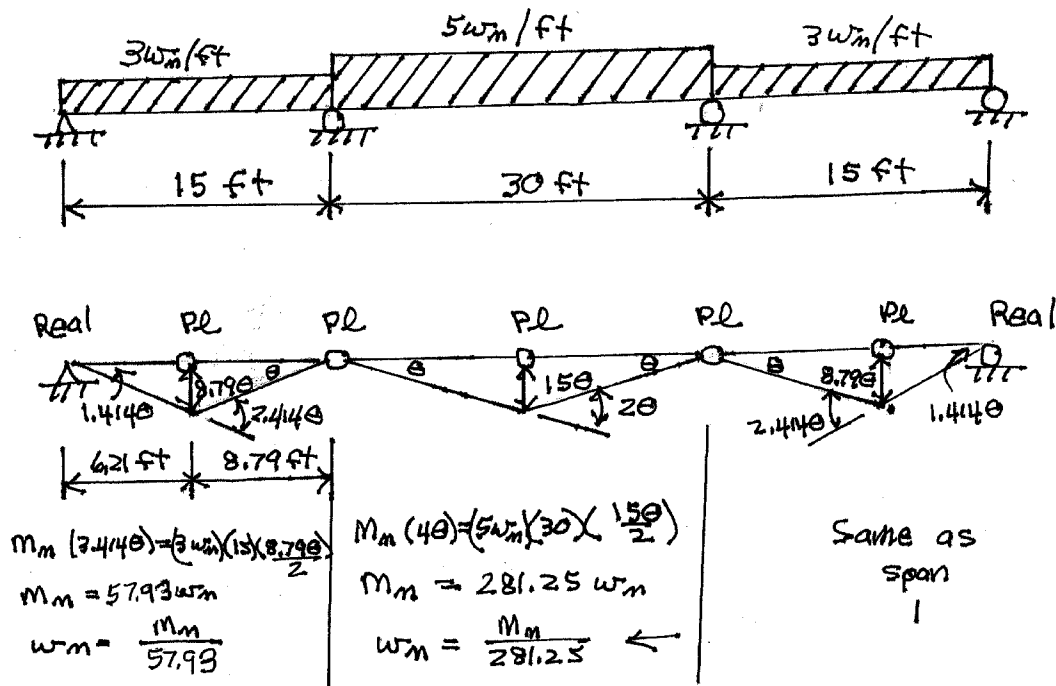
$$M_m = F_y Z = \frac{(50)(631)}{12} = 2629.2 \text{ ft-lb}$$

$$w_m = \frac{2629.2}{108} = \boxed{24.34 \text{ lb/ft}}$$

✓ g m c

EXCLUSIVE: Just in Edutruth only

PROB #8-33



using a W27X178 ($Z_x = 570\text{ in}^3$)

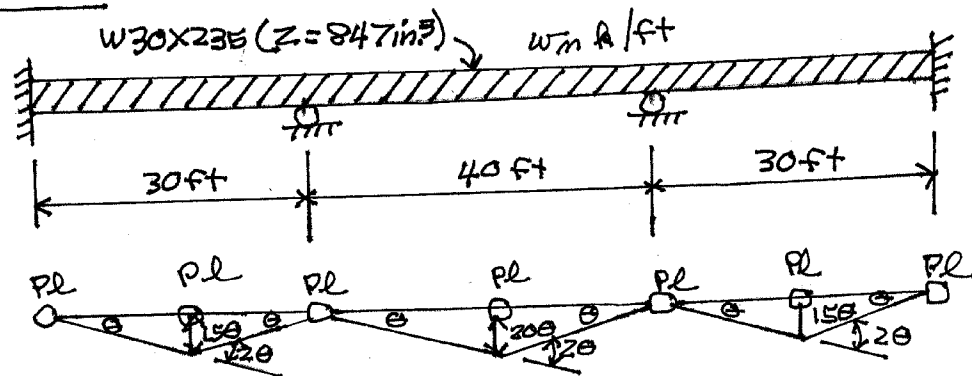
$$M_m = F_y Z = \frac{(50)(570)}{12} = 2375\text{ ft-k}$$

$$w_m = \frac{M_m}{281.25} = \frac{2375}{281.25} = \boxed{8.44\text{ k}}$$

$\checkmark \phi < \phi^c$

EXCLUSIVE: Just in Edutruth only

PROB # 8-34



$$M_m(40) = (30w_m) \left(\frac{15\theta}{2} \right) \quad M_m(40) = (40w_m) \left(\frac{20\theta}{2} \right) \quad M_m(40) = (30w_m) \left(\frac{15\theta}{2} \right)$$

$$M_m = 56.25 w_m \quad M_m = 100 w_m \quad M_m = 56.25 w_m$$

Using a $W30 \times 235$

$$M_m = F_y Z = \frac{(50)(84.7)}{12} = 3529.2 \text{ ft-k}$$

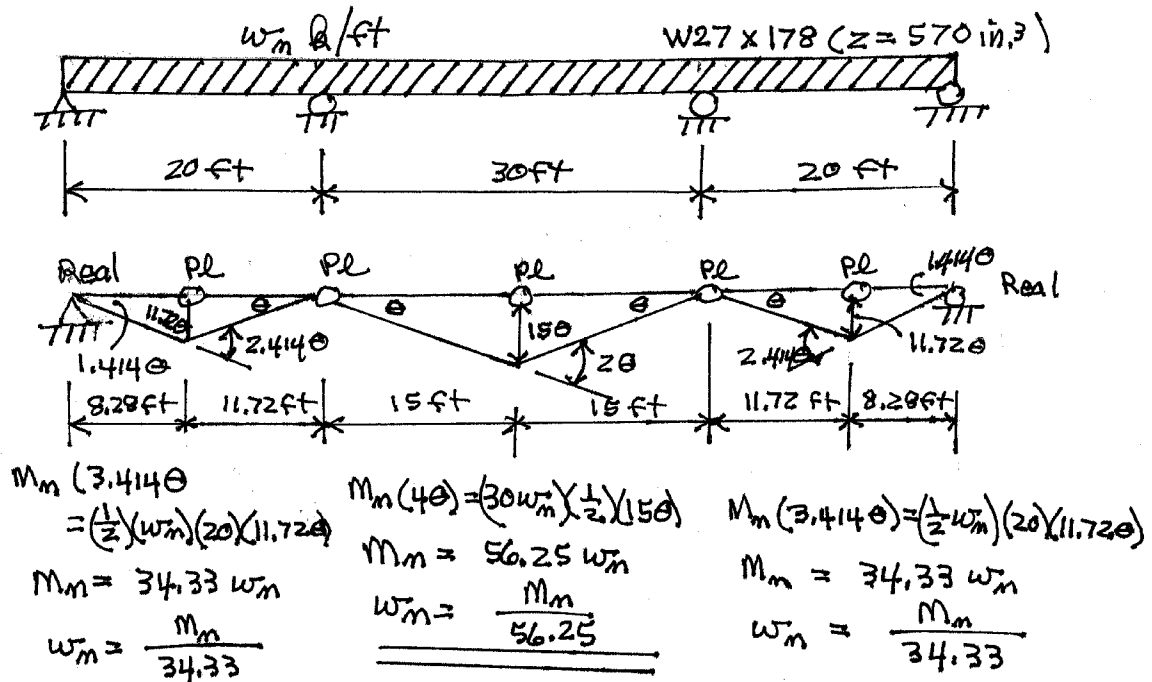
$$100 w_m = 3529.2$$

$$w_m = 35.292 \text{ k/ft}$$

\checkmark gCM^C

EXCLUSIVE: Just in Edutruth only

PROB # 8-35



Using a W27X178

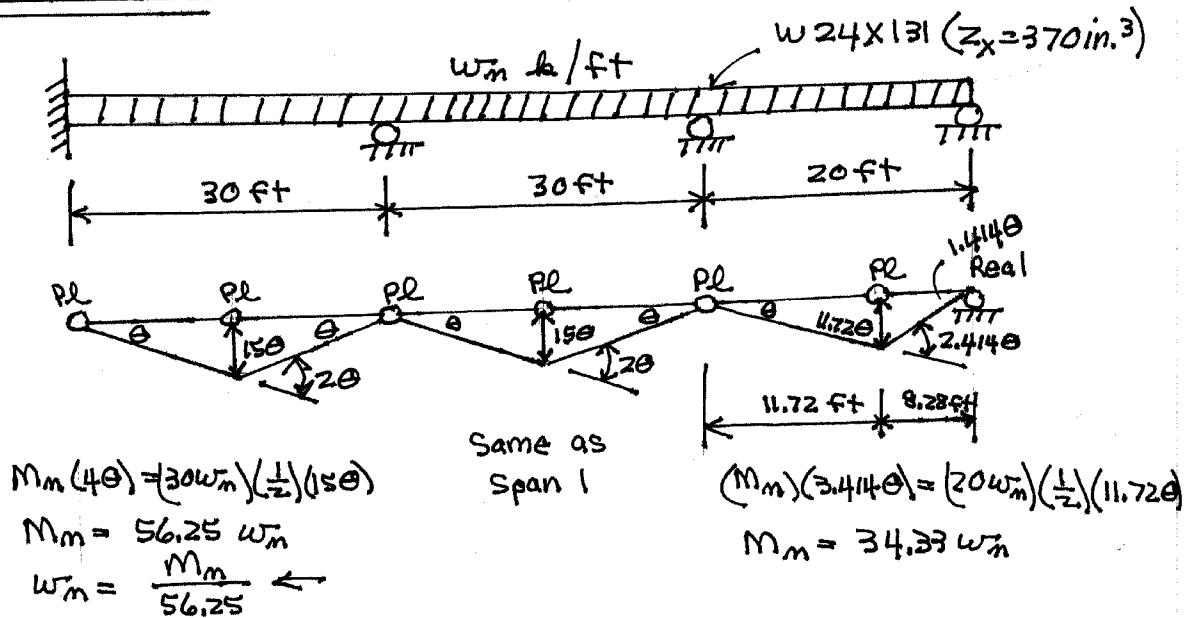
$$M_m = F_y Z = \frac{(50)(570)}{12} = 2375 \text{ ft-k}$$

$$w_m = \frac{M_m}{56.25} = \frac{2375}{56.25} = \boxed{42.22 \text{ k/ft}}$$

✓ JCM

EXCLUSIVE: Just in Edutruth only

PROB #8-36



Using a W24x131

$$M_m = F_y Z = \frac{(50)(370)}{12} = 1541.7 \text{ ft-k}$$

$$w_m = \frac{1541.7}{56.25} = \boxed{27.41 \text{ k/ft}}$$

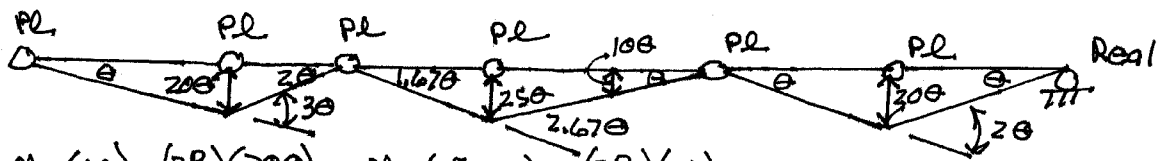
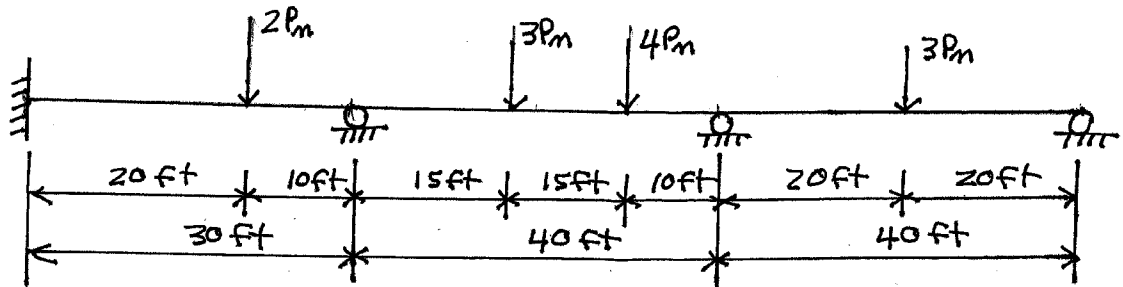
✓ $\phi < m^c$

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EXCLUSIVE: Just in Edutruth only <http://edutruth.4shared.com>

EXCLUSIVE: Just in Edutruth only

PROB #8-37



$$M_m(60) = (2P_m)(200)$$

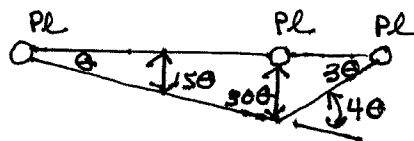
$$P_m = \frac{6}{40} M_m$$

$$M_m(5.34\theta) = (3P_m)(250) + (4P_m)(100)$$

$$P_m = \frac{5.34}{115} M_m \leftarrow$$

$$M_m(30) = (3P_m)(200)$$

$$P_m = \frac{3}{60} M_m$$



$$M_m(90) = (3P_m)(150) + (4P_m)(300)$$

$$P_m = \frac{9}{165} M_m$$

Using a W36X302 ($Z_x = 1280 \text{ in}^3$)

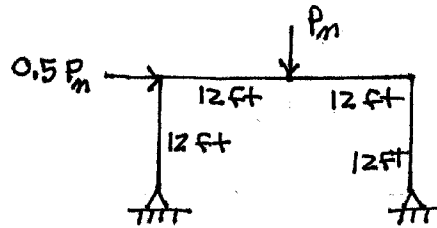
$$M_m = F_y Z = \frac{(50)(1280)}{12} = 5333 \text{ ft-k}$$

$$P_m = \left(\frac{5.34}{115} \right) (5333) = \boxed{247.6 \text{ k}}$$

✓ CMC

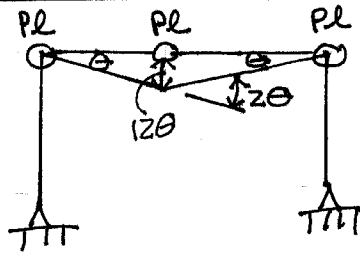
EXCLUSIVE: Just in Edutruth only

PROB# 8-38



W14X61
($Z_x = 102 \text{ in}^3$)

Beam Mechanism

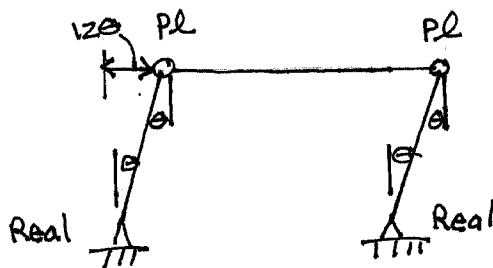


$$M_m (4\theta) = (P_m)(12\theta)$$

$$M_m = 3 P_m$$

$$P_m = \frac{1}{3} M_m$$

Sidesway Mechanism

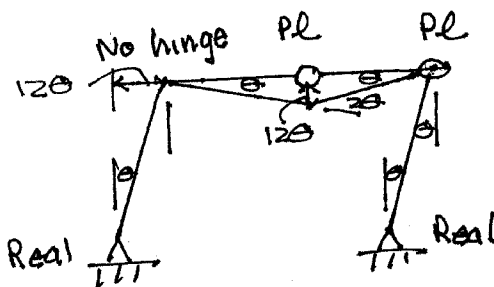


$$M_m (2\theta) = (0.5 P_m)(12\theta)$$

$$M_m = 3 P_m$$

$$P_m = \frac{1}{3} M_m$$

Combined Beam and Sidesway Mechanism



$$M_m (4\theta) = (0.5 P_m)(12\theta) + (P_m)(12\theta)$$

$$M_m = 4.5 P_m$$

$$P_m = \frac{M_m}{4.5} \leftarrow$$

Using a W14X61

$$M_m = F_y Z = \frac{(50)(102)}{12} = 425 \text{ ft-k}$$

$$P_m = \frac{425}{4.5} = \boxed{94.44 \text{ k}}$$

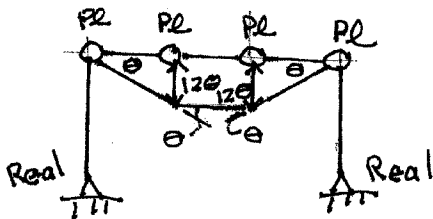
✓ $\phi < \phi_c$

EXCLUSIVE: Just in Edutruth only

PROB#8-39

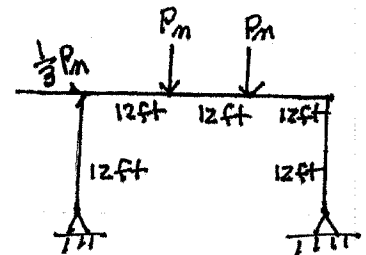
Using a W16x77 ($Z_x = 150 \text{ in}^3$)

Beam Mechanism

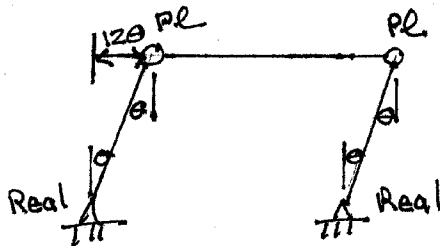


$$M_m(4\theta) = (P_m)(12\theta) + (P_m)(12\theta)$$

$$M_m = 6 P_m$$



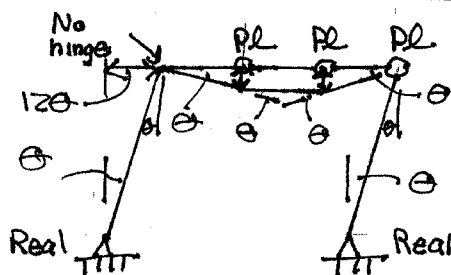
Sidesway Mechanism



$$M_m(2\theta) = \left(\frac{1}{3}P_m\right)(12\theta)$$

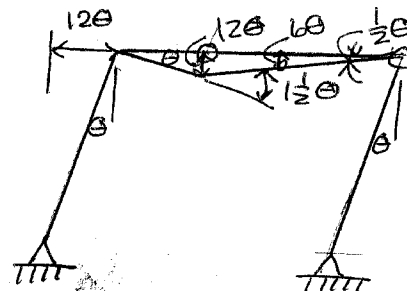
$$M_m = 2 P_m$$

Combined Beam and Sidesway Mechanisms



$$M_m(4\theta) = \left(\frac{1}{3}P_m\right)(12\theta) + (P_m)(12\theta + 12\theta)$$

$$M_m = 7 P_m \leftarrow$$



$$P_m = \frac{M_m}{7.33} = \frac{(50)(150)}{(12)(7.33)} = \boxed{85.3 \text{ k}}$$

$$M_m(3\theta) = \left(\frac{1}{3}P_m\right)(12\theta) + P_m(12\theta + 6\theta)$$

$$P_m = \frac{M_m}{7.33} \leftarrow$$

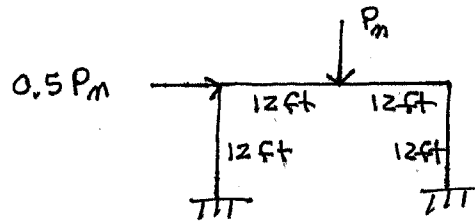
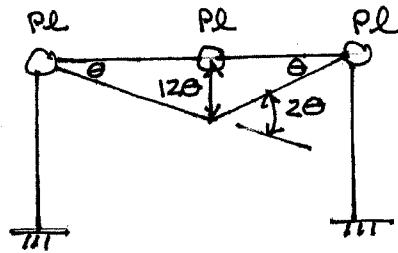
rgcm =

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EXCLUSIVE: Just in Edutruth only

PROB # 8-40

Beam Mechanism

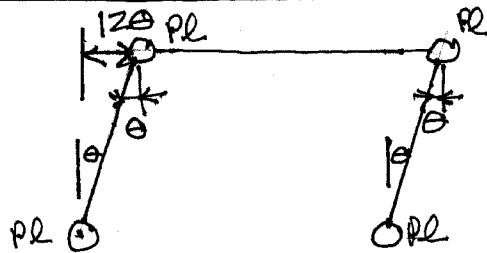


$$M_m(4\theta) = P_m(12\theta)$$

$$M_m = 3P_m$$

$$P_m = \frac{M_m}{3} \leftarrow$$

Sidesway Mechanism

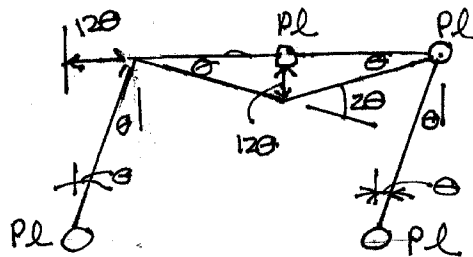


$$M_m(4\theta) = (0.5P_m)(12)$$

$$M_m = 1.5P_m$$

$$P_m = \frac{M_m}{1.5}$$

Combined Sidesway and Beam Mechanism



$$M_m(6\theta) = (0.5P_m)(12\theta) + (P_m)(12\theta)$$

$$M_m = 3P_m$$

$$P_m = \frac{M_m}{3} \leftarrow$$

Using a W14x61

$$M_m = F_y Z = \frac{(50)(102)}{12} = 425 \text{ ft-k}$$

$$P_m = \frac{425}{3} = \boxed{141.7 \text{ k}}$$

✓ JCMC

EXCLUSIVE: Just in Edutruth only

CHAPTER 9

PROB #9-1

Assume beam $w_t = 90 \text{ lbs/ft}$

LRFD	ASD
$w_u = (1.2)(1.29) + (1.6)(3) = 6.348 \text{ k/ft}$ $M_u = \frac{(6.348)(36)^2}{8} = 1028.4 \text{ ft-k}$ From AISC Table 3-2 <u>USE W30X90</u>	$w_a = 1.29 + 3 = 4.29 \text{ k/ft}$ $M_a = \frac{(4.29)(36)^2}{8} = 695 \text{ ft-k}$ From AISC Table 3-2 <u>USE W30X90</u>

✓ JCM^C

PROB #9-2

Assume beam $w_t = 68 \text{ lbs/ft}$

LRFD	ASD
$w_u = (1.2)(2.068) = 2.48 \text{ k/ft}$ $P_u = (1.6)(24) = 38.4 \text{ k}$ $M_u = \frac{(2.48)(30)^2}{8} + (38.4)(10)$ $= 663 \text{ ft-k}$ From AISC Table 3-2 <u>USE W24X68</u>	$w_a = 2.068 \text{ k/ft}$ $P_u = 24 \text{ k}$ $M_a = \frac{(2.068)(30)^2}{8} + (24)(10)$ $= 472.6 \text{ ft-k}$ From AISC Table 3-2 <u>USE W24X76</u>

✓ JCM^C

EXCLUSIVE: Just in Edutruth only

PROB #9-3

Assume beam $w_t = 84 \text{ lbs/ft}$

LRFD	ASD
$w_u = (1.2)(2.084) = 2.50 \text{ k/ft}$ $P_u = (1.6)(36) = 57.6 \text{ k}$ $M_u = \frac{(2.50)(30)^2}{8} + (10)(57.6)$ $= 857.2 \text{ ft-k}$ From AISC Table 3-2 <u>USE W27X84</u>	$w_a = 2.084 \text{ k/ft}$ $P_a = 36 \text{ k}$ $M_a = \frac{(2.084)(30)^2}{8} + (10)(36)$ $= 594.4 \text{ ft-k}$ From AISC Table 3-2 <u>USE W27X84</u>

✓ gcm

PROB #9-4

Assume beam $w_t = 84 \text{ lbs/ft}$

LRFD	ASD
$w_u = (1.2)(1.584) = 1.90 \text{ k/ft}$ $P_u = (1.6)(24) = 38.4 \text{ k}$ $\frac{1}{2}P_u = (\frac{1}{2})(38.4) = 19.2 \text{ k}$ $M_u = (1.90)(16)(8) + (38.4)(8)$ $+ (19.2)(16) = 857.4 \text{ ft-k}$ From AISC Table 3-2 <u>USE W27X84</u>	$w_a = 1.584 \text{ k/ft}$ $P_a = 24 \text{ k}$ $\frac{1}{2}P_a = 12 \text{ k}$ $M_a = (1.584)(16)(8) + (24)(8)$ $+ (12)(16) = 586.7 \text{ ft-k}$ From AISC Table 3-2 <u>USE W27X84</u>

✓ gcm

EXCLUSIVE: Just in Edutruth only

PROB #9-5

Assume beam wt = 116 lbs/ft

LRFD	ASD
$w_u = (1.2)(2.116) = 2.54 \text{ k/ft}$	$w_a = 2.116 \text{ k/ft}$
$P_u = (1.6)(15) = 24 \text{ k}$	$P_a = 15 \text{ k}$
$M_u = (2.54)(24)(12) + (24)(10+18)$ $= 1403.5 \text{ ft-k}$	$M_a = (2.116)(24)(12) + (15)(10+18)$ $= 1029.4 \text{ ft-k}$
From AISC Table 3-2 <u>USE W30X116</u>	From AISC Table 3-2 <u>USE W33X118</u>

✓ gcm

EXCLUSIVE: Just in Edutruth only

PROB#9-6

Assume beam wt = 55 lbs/ft

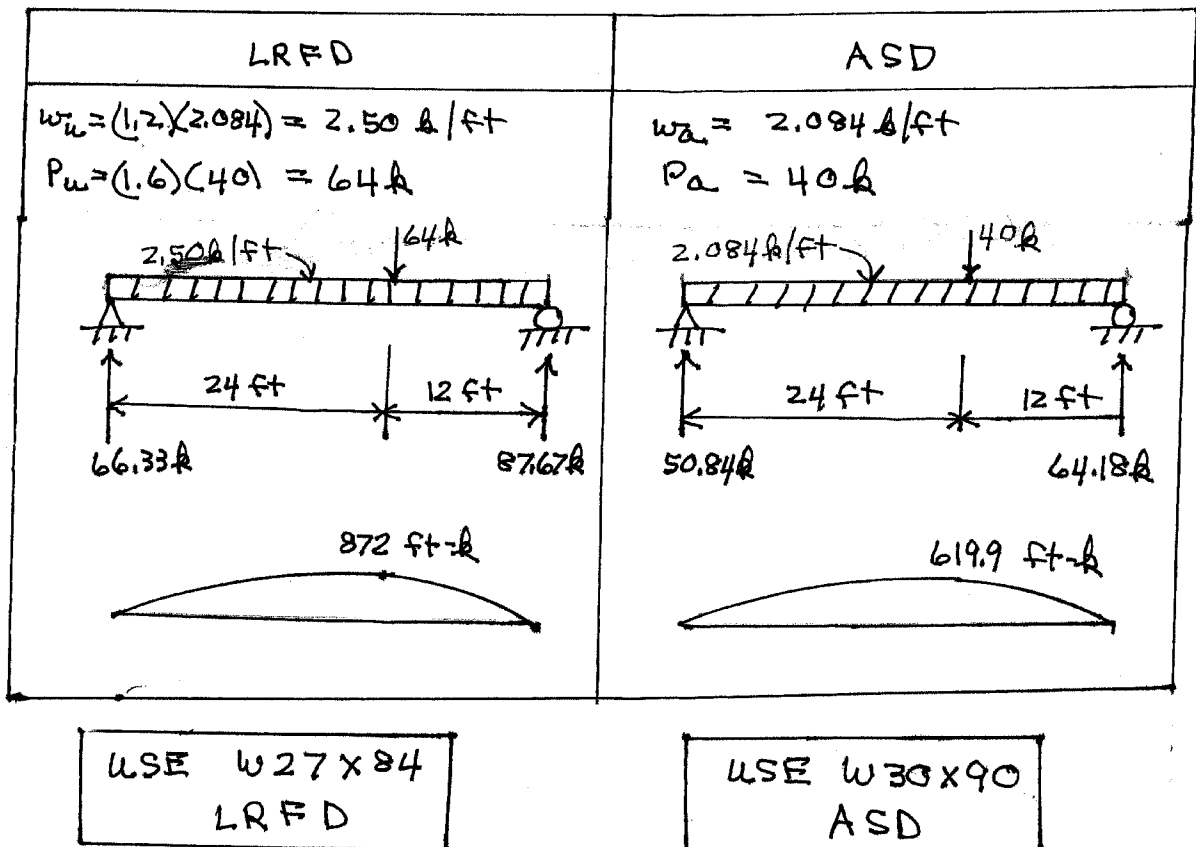
LRFD	ASD
$w_u = (1.2)(1.055) + (1.6)(2) = 4.466 \text{ k/ft}$ $P_u = (1.6)(30) = 48 \text{ k}$	$w_a = 1.055 + 2 = 3.055 \text{ k/ft}$ $P_a = 30 \text{ k}$
<div style="border: 1px solid black; padding: 5px; width: fit-content;"> From AISC Table 3-2 USE W27X84 </div>	<div style="border: 1px solid black; padding: 5px; width: fit-content;"> From AISC Table 3-2 USE W27X84 </div>

✓ gcm

EXCLUSIVE: Just in Edutruth only

PROB #9-7

Assume beam $w_t = 84 \text{ lbs/ft}$



$\checkmark \phi < m \equiv$

200

EXCLUSIVE: Just in Edutruth only

PROB #9-8

(a) Design of beams

Assume bm wt

$$= 76 \text{ lbs/ft}$$

$$\text{Concrete slab} = \left(\frac{6}{12}\right)(150)(15)$$

$$= 1125$$

w_D

$$= 1201 \text{ lbs/ft}$$

$$w_L = (120)(15)$$

$$= 1800 \text{ lbs/ft}$$

LRFD	ASD
$w_u = (1.2)(1201) + (1.6)(1800) = 4321 \text{ lb/ft}$	$w_a = 1201 + 1800 = 3001 \text{ lb/ft}$
$M_u = \frac{(4321)(38)^2}{8} = 779.9 \text{ ft-k}$	$M_a = \frac{(3001)(38)^2}{8} = 541.7 \text{ ft-k}$
From AISC Table 3-2	From AISC Table 3-2
USE W24 X 84 for beams	USE W24 X 84 for beams

(b) Design of girders

Assume girder wt = 167 lbs/ft

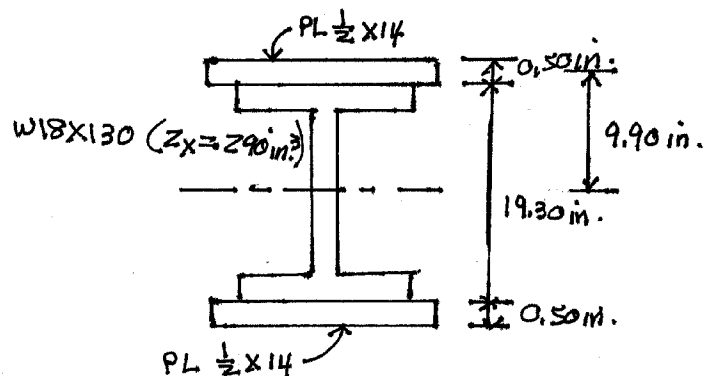
LRFD	ASD
$w_u = (1.2)(0.167) = 0.2004 \text{ k/ft}$	$w_a = 0.167 \text{ k/ft}$
$P_u = (2)(19)(4321) = 164.2 \text{ k}$	$P_a = (2)(19)(3001) = 114.04 \text{ k}$
$M_u = \frac{(0.2004)(45)^2}{8} + (15)(164.2)$	$M_a = \frac{(0.167)(45)^2}{8} + (15)(114.04)$
$= 2514 \text{ ft-k}$	$= 1753 \text{ ft-k}$
USE W40 X 167	USE W36 X 182

✓ $\phi < M_u$

201

EXCLUSIVE: Just in Edutruth only

PROB # 9-9



$$Z_x = 290 + (2) \left(\frac{1}{2} \right) (14) (9.90) = 428.6 \text{ in}^3$$

$$\text{Beam wt} = 130 + \frac{(2) \left(\frac{1}{2} \right) (14) (490)}{144} = 172.6 \text{ lbs/ft}$$

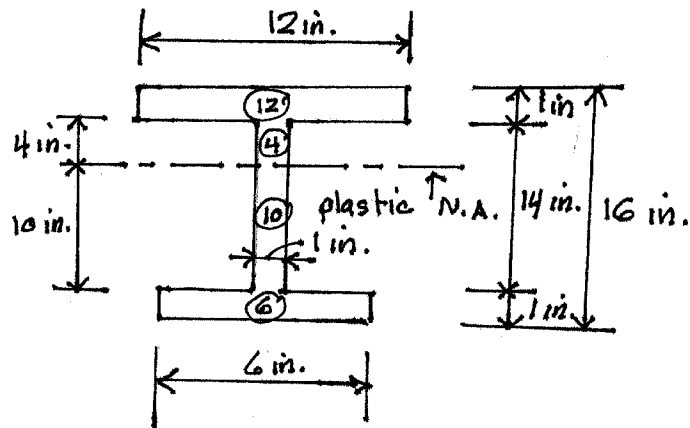
$$M_m = F_y Z = \frac{(50)(428.6)}{12} = 1785.8 \text{ ft-k}$$

LRFD $\phi_b = 0.90$	ASD $\Omega_b = 1.67$
$\phi_b M_m = (0.90)(1785.8) = 1607.2 \text{ ft-k}$	$\frac{M_m}{\Omega_b} = \frac{1785.8}{1.67} = 1069.3 \text{ ft-k}$
$\frac{(w_u)(40)^2}{8} = 1607.2$	$\frac{(w_a)(40)^2}{8} = 1069.3$
$w_u = 8.036 \text{ k/ft}$	$w_a = 5.346 \text{ k/ft}$
$-1.2 \text{ beam wt} = -0.213$	$- \text{Beam wt} = -0.1776$
$\text{Net } w_u = 7.823 \text{ k/ft}$	$\text{Net } w_a = 5.168 \text{ k/ft}$

$\checkmark \text{ gcm}^c$

EXCLUSIVE: Just in Edutruth only

PROB #9-10



$$A = (12)(1) + (6)(1) + (14)(1) = 32 \text{ in.}^2$$

Plastic N.A. located an area $\frac{32}{2} = 16.0 \text{ in.}$ from top or bottom.

$$Z = (12)(4.5) + (4)(2) + (10)(5) + (6)(10.5) = 175 \text{ in.}^3$$

$$M_m = \frac{F_y Z}{12} = \frac{(50)(175)}{12} = 729.2 \text{ ft-k}$$

$$\text{Weight} = \frac{32}{144} (49.0) = 108.9 \text{ lbs/ft}$$

LRFD $\phi_b = 0.90$	ASD $\Omega_b = 1.67$
$\phi M_m = (0.90)(729.2)$ $= 656.3 \text{ ft-k}$ $\frac{(w_u)(30)^2}{8} = 656.3$ $w_u = 5.834 \text{ k/ft}$ $(1.2)(1.1089) + 1.6w_L = 5.834$ $w_L = 2.814 \text{ k/ft}$	$\frac{M_m}{\Omega_b} = \frac{729.2}{1.67}$ $= 436.6 \text{ ft-k}$ $\frac{(w_a)(30)^2}{8} = 436.6$ $w_a = 3.881 \text{ k/ft}$ $1.1089 + w_L = 3.881$ $w_L = 2.772 \text{ k/ft}$

✓ $\phi M_m \leq$

203

EXCLUSIVE: Just in Edutruth only

PROB # 9-11

Assume beam wt = 124 lbs/ft

LRFD	ASD
$w_u = (1.2)(2.624) + (1.6)(2) = 6.35 \text{ k/ft}$	$w_a = 2.624 + 2 = 4.624 \text{ k/ft}$
$M_u = \frac{(6.35)(36)^2}{8} = 1029.7 \text{ ft-k}$	$M_a = \frac{(4.624)(36)^2}{8} = 749 \text{ ft-k}$

$$Z_{\text{Reqd}} = \frac{M_u}{\phi_b F_y} = \frac{(12)(1029.7)}{(0.9)(36)} = 381 \text{ in}^3$$

Try W 33 x 118 ($b_f = 11.5 \text{ in.}$, $t_f = 0.740 \text{ in.}$, $S_x = 359 \text{ in}^3$, $Z_x = 415 \text{ in}^3$)

$$A_{fg} \rightarrow b_f t_f = (11.5)(0.740) = 8.51 \text{ in}^2$$

$$A_{fm} = 8.51 - (2)(\frac{1}{8})(0.740) = 6.945 \text{ in}^2$$

$$F_u A_{fm} = (58)(6.945) = 397 \text{ k}$$

$$\frac{F_y}{F_u} = \frac{36}{58} = 0.62 < 0.8 \therefore \phi_t = 1.0$$

$$397 \text{ k} > \phi_t F_y A_{fg} = (1.0)(36)(8.51) = 306.4 \text{ k}$$

\therefore Tensile rupture does not apply

$$M_m = F_y Z_x = \frac{(36)(415)}{12} = 1245 \text{ ft-k}$$

LRFD $\phi_b = 0.90$	ASD $\Omega_b = 1.67$
$\phi_b M_m = (0.9)(1245) = 1120 \text{ ft-k}$ $> 1029.7 \text{ ft-k}$ OK	$\frac{M_m}{\Omega_b} = \frac{1245}{1.67} = 745.1 \text{ ft-k}$ $< 749 \text{ ft-k}$

USE W 33 x 118

USE W 33 x 130

✓ g cm

204

EXCLUSIVE: Just in Edutruth only

PROB #9-12

Assume beam $w_t = 116 \text{ lbs/ft}$

LRFD	ASD
$w_u = (1.2)(2.616) + (1.6)(2) = 6.34 \text{ k/ft}$	$w_a = 2.616 + 2 = 4.616 \text{ k/ft}$
$M_u = \frac{(6.34)(36)^2}{8} = 1027 \text{ ft-k}$	$M_a = \frac{(4.616)(36)^2}{8} = 747.8 \text{ ft-k}$

$$Z_{\text{Reqd}} = \frac{(12)(1027)}{(0.9)(50)} = 273.9 \text{ in}^3$$

Try $W33 \times 118$ ($b_f = 11.5 \text{ in.}$, $t_f = 0.740 \text{ in.}$, $S_x = 359 \text{ in}^3$, $Z_x = 415 \text{ in}^3$)

$$A_{fg} = b_f t_f = (11.5)(0.740) = 8.51 \text{ in}^2$$

$$A_{fm} = 8.51 - (4)(\frac{1}{8})(0.740) = 5.18 \text{ in}^2$$

$$F_u A_{fm} = (65)(5.18) = 336.7 \text{ k}$$

$$\frac{F_y}{F_u} = \frac{50}{65} = 0.769 < 0.8 \therefore \phi_t = 1.0$$

$$336.7 < \phi_t F_y A_{fg} = (1.0)(50)(8.51) = 425.5 \text{ k}$$

\therefore Tensile rupture of the tension flange does apply

$$M_m = \frac{F_u A_{fm}}{A_{fg}} S_x = \frac{(65)(5.18)}{8.51} (359) = 14,204 \text{ in-k} = 1184 \text{ ft-k}$$

LRFD $\phi_b = 0.90$	ASD $\Omega_b = 1.67$
$\phi_b M_m = (0.90)(1184) = 1065.6 \text{ ft-k}$ $> 1027 \text{ ft-k}$ OK	$\frac{M_m}{\Omega_b} = \frac{1184}{1.67} = 709 \text{ ft-k} < 750 \text{ ft-k}$ N.G.

USE $W33 \times 118$

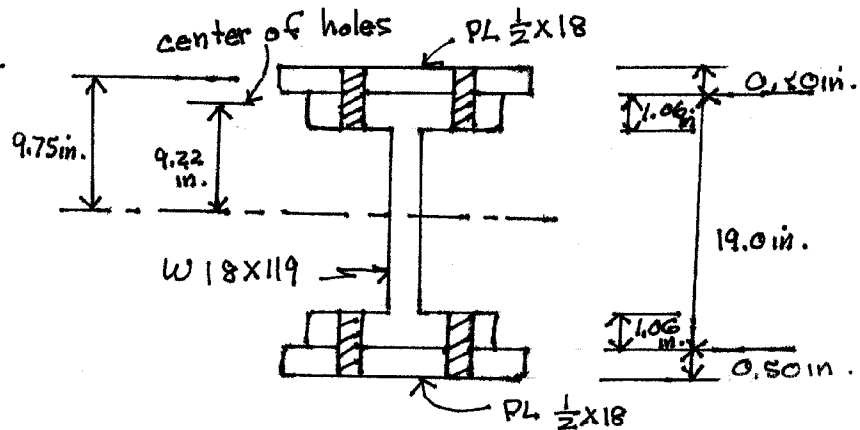
USE $W33 \times 130$

✓ $CM \leq$

205

EXCLUSIVE: Just in Edutruth only

PROB # 9-13



Using a W18x119 ($Z_x = 262 \text{ in}^3$)

$$Z_{net} = 262 + (2)(\frac{1}{2} \times 18)(9.75) - (4)(1 + \frac{1}{8})(1.56)(9.22) = 372.8 \text{ in}^3$$

$$M_m = F_y Z = \frac{(50)(372.8)}{12} = 1553.3 \text{ ft-k}$$

$$B_m \omega_t = 119 + \frac{(2)(\frac{1}{2} \times 18)(490)}{144} = 180.25 \text{ lbs/ft}$$

LRFD $\phi_b = 0.90$	ASD $\Omega_b = 1.67$
$\phi_b M_m = (0.90)(1553.3) = 1398 \text{ ft-k}$ $\frac{w_u L^2}{8} = 1398$ $w_u = \frac{(8)(1398)}{(30)^2} = 12.427 \text{ k/ft}$ $\text{Net } w_u = 12.427 - (1.2)(0.18025)$ $= \boxed{12.21 \text{ k/ft}}$	$\frac{M_m}{\Omega_b} = \frac{1553.3}{1.67} = 930.1 \text{ ft-k}$ $\frac{w_a L^2}{8} = 930.1$ $w_a = \frac{(8)(930.1)}{900} = 8.268 \text{ k/ft}$ $\text{Net } w_a = 8.268 - 0.18025$ $= \boxed{8.09 \text{ k/ft}}$

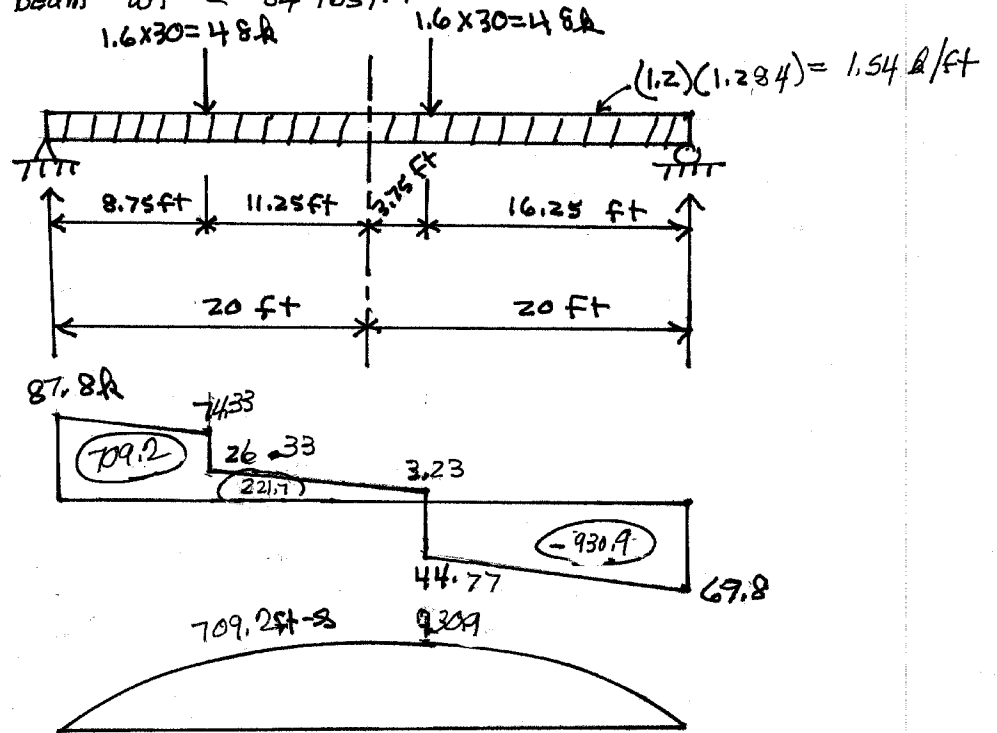
✓ gcm

206

EXCLUSIVE: Just in Edutruth only

PROB# 9-14

Place live loads as shown on sketch
assuming beam wt = 84 lbs/ft



$$Z_{Reqd} = \frac{M_u}{\phi_b F_y}$$

$$Z_{Reqd} = \frac{(12)(930.9)}{(0.9)(50)} = 248.2 \text{ in.}^3$$

USE W 30 X 90

✓ JCM

207

EXCLUSIVE: Just in Edutruth only

PROB #9-15

Using a W21X73 ($\phi_b M_{px} = 645 \text{ ft-k}$, $\frac{M_{px}}{\Omega_b} = 429 \text{ ft-k}$,

$\phi_b M_{rx} = 396 \text{ ft-k}$, $\frac{M_{rx}}{\Omega_b} = 264 \text{ ft-k}$, $L_p = 6.39 \text{ ft}$, $L_r = 19.2 \text{ ft}$,

BF for LRFD = 19.4 k, BF for ASD = 12.9 k, $\lambda_{cs} = 2.19$,

$J = 3.02 \text{ in.}^4$, $C = 1.0$ for doubly sym I section, $S_x = 151 \text{ in.}^3$,

$h_o = 20.5 \text{ in.}$)

For 6 ft unbraced length

$$L_b = 6 \text{ ft} < L_p$$

LRFD	ASD
$\phi_b M_p = \underline{645 \text{ ft-k}}$	$\frac{M_m}{\phi_b} = \underline{429 \text{ ft-k}}$

For 12 ft unbraced length

$$L_b = 12 \text{ ft} > L_p < L_r$$

LRFD	ASD
$\phi_b M_{mx} = C_b [\phi_b M_{px} - \text{BF}(L_b - L_p)]$ $\leq \phi_b M_{px}$ $\phi_b M_{mx} = 1.0 [645 - (19.4)(12 - 6.39)]$ $= \underline{536.2 \text{ ft-k}}$	$\frac{M_{mx}}{\Omega_b} = C_b \left[\frac{M_{px}}{\Omega_b} - \text{BF}(L_b - L_p) \right]$ $\leq \frac{M_{px}}{\Omega_b}$ $\frac{M_{mx}}{\Omega_b} = 1.0 [429 - (12.9)(12 - 6.39)]$ $= \underline{356.6 \text{ ft-k}}$

EXCLUSIVE: Just in Edutruth only

PROB #9-15 CONTD.

For 22 ft Unbraced Length

$$L_b = 22 \text{ ft} > L_c \text{ of } 19.2 \text{ ft}$$

$$F_{cr} = \frac{C_b \pi^2 E}{\left(\frac{L_b}{r_{t4}}\right)^2} \sqrt{1 + 0.078 \frac{J_c}{S_x h_o} \left(\frac{L_b}{r_{t4}}\right)^2}$$

$$= \frac{(1.0)(\pi)^2 (29 \times 10^3)}{\left(\frac{12 \times 22}{2.19}\right)^2} \sqrt{1 + 0.078 \frac{(3.02)(1.0)}{(151)(20.5)} \left(\frac{12 \times 22}{2.19}\right)^2}$$

$$= 28.585 \text{ ksi}$$

$$M_{mx} = F_{cr} S_x = \frac{(28.585)(151)}{12} = 359.7 \text{ ft-k}$$

LAFD $\phi_b = 0.9$	ASD $\Omega_b = 1.67$
$\phi_b M_{mx} = (0.9)(359.7) = 323.7 \text{ ft-k}$	$\frac{M_{mx}}{\Omega_b} = \frac{359.7}{1.67} = 215.4 \text{ ft-k}$

✓ O.K.

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EXCLUSIVE: Just in Edutruth only

PROB # 9-16

Assume beam wt = 100 lbs/ft

LRFD	ASD
$w_u = (1.2)(2.3) + (1.6)(3.0) = 7.56 \text{ k/ft}$ $M_u = \frac{(7.56)(25)^2}{8} = 590.6 \text{ ft-k}$ $C_b = 1.14$ (Figure 9-10 in text) Enter AISC Table 3-10 with $M_{u \text{ effective}} = \frac{590.6}{1.14} = 518.1 \text{ ft-k}$ Try W18x97 $\phi_b M_{np} = 791 > 518.1$ <u>OK</u> <div style="border: 1px solid black; padding: 2px; display: inline-block;">USE W18x97</div>	$w_a = 2.3 + 3.0 = 5.3 \text{ k/ft}$ $M_a = \frac{(5.3)(25)^2}{8} = 414.1 \text{ ft-k}$ $C_b = 1.14$ (Figure 9-10 in text) Enter AISC Table 3-10 with $M_{a \text{ effective}} = \frac{414.1}{1.14} = 363.2 \text{ ft-k}$ Try W18x97 $\frac{M_{px}}{\phi_b} = 526 > 414.1$ <div style="border: 1px solid black; padding: 2px; display: inline-block;">USE W18x97</div>

✓ $\phi_b M_{np} > M_{a \text{ effective}}$

PROB # 9-17

Assume beam wt = 117 lbs/ft

LRFD	ASD
$w_u = (1.2)(1.117) = 1.34 \text{ k/ft}$ $P_u = (1.6)(40) = 64 \text{ k}$ $M_u = \frac{(1.34)(30)^2}{8} + (64)(10) = 790.8 \text{ ft-k}$ From AISC Table 3-10 <div style="border: 1px solid black; padding: 2px; display: inline-block;">USE W24x131</div>	$w_a = 1.117 \text{ k/ft}$ $P_a = 40 \text{ k}$ $M_a = \frac{(1.117)(30)^2}{8} + (40)(10) = 525.7 \text{ ft-k}$ From AISC Table 3-10 <div style="border: 1px solid black; padding: 2px; display: inline-block;">USE W24x131</div>

✓ $\phi_b M_{np} > M_{a \text{ effective}}$

EXCLUSIVE: Just in Edutruth only

PROB# 9-18

Assume beam wt = 84 lbs/ft

LRFD	ASD
$w_u = (1.2)(1.084) = 1.301 \text{ k/ft}$ $P_u = (1.6)(40) = 64 \text{ k}$ $M_u = \frac{(1.301)(30)^2}{8} + 64(10) = 786.25 \text{ ft-k}$ Note $C_b = 1.0$ for middle section Using AISC Table 3-10 <u>USE W27X84</u>	$w_a = 1.084 \text{ k/ft}$ $P_a = 40 \text{ k}$ $M_a = \frac{(1.084)(30)^2}{8} + (40)(10) = 522 \text{ ft-k}$ Note $C_b = 1.0$ for middle section Using AISC Table 3-10 <u>USE W24X84</u>

✓ JCM

PROB# 9-19

Using a W30X173

From AISC Table 3-10

$$\phi_b M_{mx} = 1730 \text{ ft-k}$$

$$\frac{M_{mx}}{\Omega_b} = 1153 \text{ ft-k}$$

LRFD	ASD
$C_b = 1.32$ (Text Figure 9-10) $C_b \phi_b M_{mx} = (1.32)(1730) = 2284 \text{ ft-k}$ $> \phi_b M_{px} = 2280$ Use 2280 $\frac{(1.2)(0.173)(27)^2}{8} + \frac{(1.6 P_L)(27)}{4} = 2280$ <u>$P_L = 209.4 \text{ k}$</u>	$C_b = 1.32$ (Text Figure 9-10) $C_b \frac{M_{mx}}{\Omega_b} = (1.32)(1153) = 1522 \text{ ft-k}$ $> \frac{M_{px}}{\Omega_b} = 1510$ Use 1510 $\frac{(0.173)(27)^2}{8} + \frac{(P_L)(27)}{4} = 1510$ <u>$P_L = 221.4 \text{ k}$</u>

✓ JCM

EXCLUSIVE: Just in Edutruth only

PROB# 9-20

Using a W30X173 ($\phi_b M_{px} = 2280 \text{ ft-k}$, $\frac{M_{px}}{\Omega_b} = 1510 \text{ ft-k}$)

$C_b = 1.67$ from Text Figure 9-10
 $\phi_b M_{mx} = 2230 \text{ ft-k}$ and $\frac{M_{mx}}{\Omega_b} = 1510 \text{ ft-k}$ AISC Figure 3-10

LRFD	ASD
$C_b \phi_b M_{mx} = (1.67)(2230) = 3724 \text{ ft-k}$ But may not be larger than $\phi_b M_{px} = 2280 \text{ ft-k}$ $\frac{w_u L^2}{8} + \frac{(P_u)(L)}{4} = 2280$ $\frac{(1.2)(0.173)(27)^2}{8} + \frac{(1.6 P_L)(27)}{4} = 2280$ $P_L = 209.4 \text{ k}$	$C_b \frac{M_{mx}}{\Omega_b} = (1.67) \left(\frac{M_{mx}}{\Omega_b} \right) = (1.67) \left(\frac{1510}{1.67} \right) = 2484 \text{ k}$ But may not be larger than $\frac{M_{px}}{\Omega_b} = 1510 \text{ ft-k}$ $\frac{w_a L^2}{8} + \frac{(P_a)(L)}{4} = 1510$ $\frac{(0.173)(27)^2}{8} + \frac{(P_a)(27)}{4} = 1510$ $P_a = 221.4 \text{ k}$

PROB# 9-21

Assume beam wt = 90 lbs/ft

Noting $C_b = 1.0$ from Text Figure 9-10

LRFD	ASD
$w_u = (1.2)(0.090) = 0.108 \text{ k/ft}$ $P_u = (1.6)(30) = 48 \text{ k}$ $M_u = (0.108)(15)(7.5) + (48)(15)$ $= 732 \text{ ft-k}$ Entering AISC Table 3-10 with $M_u = 732 \text{ ft-k}$ and $L_{unbr} = 15 \text{ ft}$ USE W30X90	$w_a = 0.09 \text{ k/ft}$ $P_a = 30 \text{ k}$ $M_a = (0.09)(15)(7.5) + (30)(15)$ $= 460 \text{ ft-k}$ Entering AISC Table 3-10 with $M_a = 460 \text{ ft-k}$ and $L_{unbr} = 15 \text{ ft}$ USE W27X84

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EXCLUSIVE: Just in Edutruth only

PROB #9-22

(a) Compression flange of W33x118 is fully braced

LRFD	ASD
$w_u = (1.2)(0.118) + (1.6)(w_L) = 0.1416 + 1.6w_L$ $M_u = \frac{(0.1416)(24)^2}{8} + \frac{(1.6w_L)(24)^2}{8}$ $= 10.195 + 115.2 w_L$ From AISC Table 3-2 $\phi_b M_m = M_u = 1560 \text{ ft-k}$ $10.195 + 115.2 w_L = 1560$ $w_L = 13.45 \text{ k/ft}$	$w_a = 0.118 + w_L$ $M_a = \frac{(0.118)(24)^2}{8} + \frac{(w_L)(24)^2}{8}$ $= 8.496 + 72 w_L$ From AISC Table 3-2 $\frac{M_m}{\Omega_b} = 1040 \text{ ft-k}$ $8.496 + 72 w_L = 1040$ $w_L = 14.33 \text{ k/ft}$

(b) Compression flange braced @ ends only

LRFD	ASD
$w_u = (1.2)(0.118) + 1.6 w_L$ $= 0.1416 + 1.6 w_L$ $M_u = \frac{(0.1416)(24)^2}{8} + \frac{(1.6 w_L)(24)^2}{8}$ $= 10.195 + 115.2 w_L$ From AISC Table 3-10 $\phi_b M_m = 913 \text{ ft-k}$ $C_b \phi_b M_m = (1.14)(913) = 1041 \text{ ft-k}$ $< \phi_b M_{px} = 1530 \text{ ft-k}$ $10.195 + 115.2 w_L = 1041$ $w_L = 8.95 \text{ k/ft}$	$w_a = 0.118 + w_L$ $M_a = \frac{(0.118)(24)^2}{8} + \frac{(w_L)(24)^2}{8}$ $= 8.496 + 72 w_L$ From AISC Table 3-10 $\frac{M_m}{\Omega_b} = 608 \text{ ft-k}$ $C_b \frac{M_m}{\Omega_b} = (1.14)(608)$ $= 693.1 \text{ ft-k} < \frac{M_{px}}{\Omega_b} = 1040 \text{ ft-k}$ $8.496 + 72 w_L = 693$ $w_L = 9.58 \text{ k/ft}$

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VJCME

EXCLUSIVE: Just in Edutruth only

PROB #9-23

using a W18x97 ($\phi_b M_{px} = 791 \text{ ft-k}$, $\frac{M_{px}}{\Omega_b} = 526 \text{ ft-k}$)

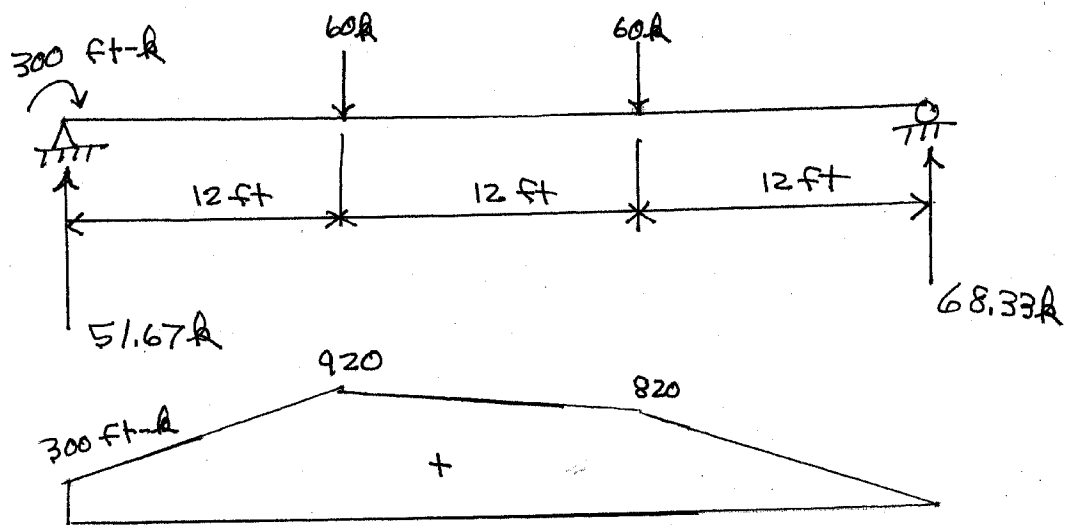
LAFD	ASD
$w_u = (1.2)(1.097) + 1.6 w_L$ $= 1.316 + 1.6 w_L$ $M_u = \frac{(1.316)(30)^2}{8} + \frac{(1.6 w_L)(30)^2}{8}$ $= 148.05 + 180 w_L$ $C_b = 1.14$ <p>From AISC Table 3-10</p> $\phi_b M_m = 498 \text{ ft-k}$ $C_b \phi_b M_m = (1.14)(498)$ $= 567.7 \text{ ft-k} < \phi_b M_{px} = 791 \text{ ft-k}$ $148.05 + 180 w_L = 567.7$ <div style="border: 1px solid black; padding: 2px; display: inline-block;"> $w_L = 2.33 \text{ k/ft}$ </div>	$w_a = 1.097 + w_L$ $M_a = \frac{(1.097)(30)^2}{8} + \frac{(w_L)(30)^2}{8}$ $= 123.41 + 112.5 w_L$ $C_b = 1.14$ <p>From AISC Table 3-10</p> $\frac{M_m}{\Omega_b} = 332 \text{ ft-k}$ $C_b \frac{M_m}{\Omega_b} = (1.14)(332) = 378.5 \text{ ft-k}$ $< \frac{M_{px}}{\Omega_b} = 526 \text{ ft-k}$ $123.41 + 112.5 w_L = 378.5$ <div style="border: 1px solid black; padding: 2px; display: inline-block;"> $w_L = 2.27 \text{ k/ft}$ </div>

✓ JCM

EXCLUSIVE: Just in Edutruth only

PROB# 9-24

FOR LAFD ONLY



Referring to AISC Table 3-2 for a W30X90

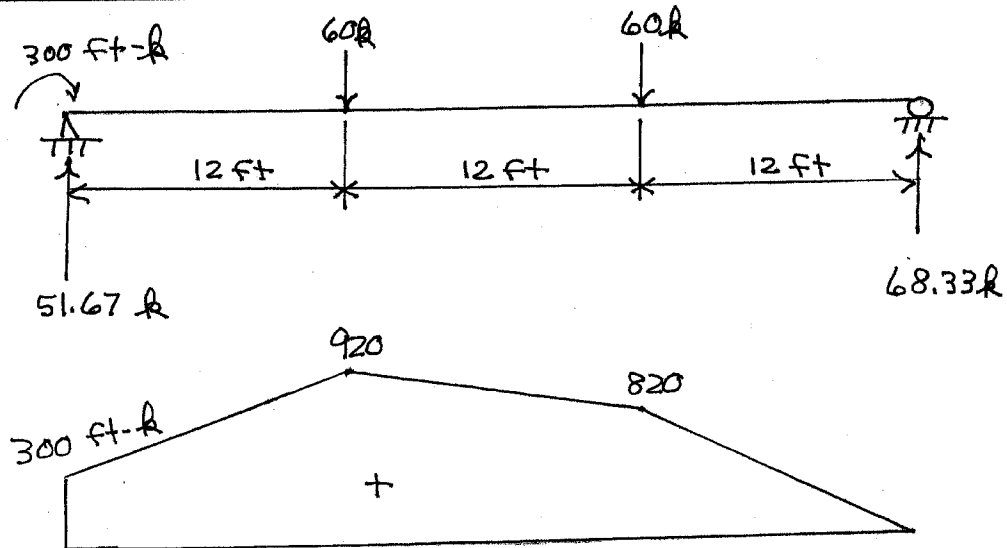
$$\phi_b M_{px} = 1060 \text{ ft-k} > 920 \text{ ft-k} \quad \underline{\text{OK}}$$

✓ gcm

EXCLUSIVE: Just in Edutruth only

PROB# 9-25

FOR LRFD ONLY



$$C_b = \frac{(12.5)(920)}{(2.5)(920) + (3)(455) + (4)(610) + (3)(765)} = 1.37$$

$$M_u \text{ for use in Table 3-10 (AISC)} = \frac{920}{1.67} = 551 \text{ ft-k}$$

Try W24x62 but its $\phi_b M_{px} = 574 \text{ ft-k} < 920 \text{ ft-k}$

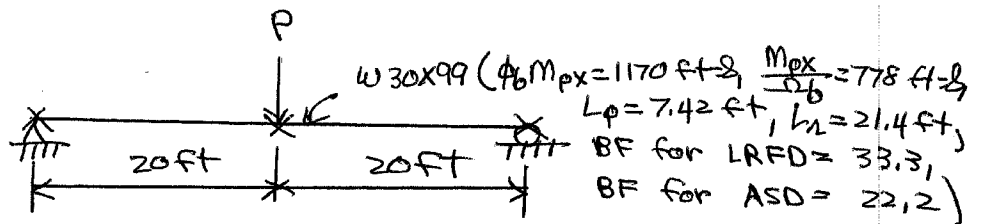
USE W30x90

✓ $\phi_b M_{px} \leq$

216

EXCLUSIVE: Just in Edutruth only

PROB #9-26



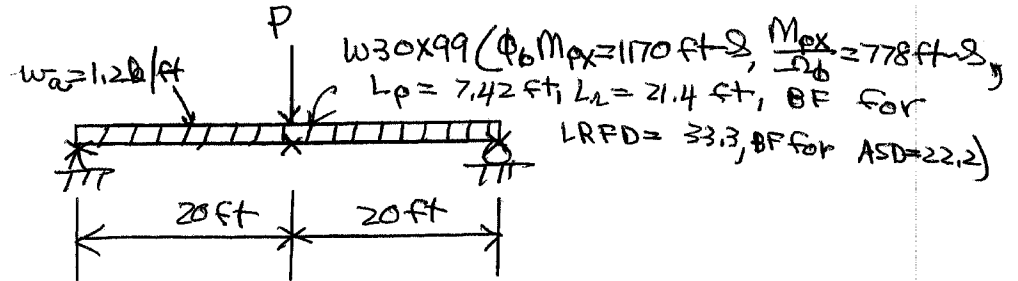
Neglecting beam wt

LRFD	ASD
<p>Noting $L_b > L_p < L_2$ and $C_b = 1.67$</p> $C_b \phi_b M_m = C_b [\phi_b M_{px} - BF(L_b - L_p)]$ $\leq \phi_b M_m$ $= (1.67) [1170 - 33.3(20 - 7.42)]$ $= 1254.3 \text{ ft-lb} > \phi_b M_m$ <p>\therefore Use <u>1170 ft-lb</u></p> $\frac{(P_u)(40)}{4} = 1170$ $P_u = 117 \text{ ft-lb}$ $1.6P_L = P_u = 117$ <div style="border: 1px solid black; padding: 2px; display: inline-block;"> $P_L = 73.12 \text{ k}$ </div>	<p>Noting $L_b > L_p < L_2$ and $C_b = 1.67$</p> $C_b \frac{M_m}{\Omega_b} = C_b \left[\frac{M_{px}}{\Omega_b} - BF(L_b - L_p) \right]$ $\leq \frac{M_{px}}{\Omega_b}$ $C_b \frac{M_{mx}}{\Omega_b} = 1.67 [778 - 22.2(20 - 7.42)]$ $= 832.9 \text{ ft-lb} > \frac{M_{px}}{\Omega_b} = 778 \text{ ft-lb}$ <p>\therefore Use <u>778 ft-lb</u></p> $\frac{(P_a)(40)}{4} = 778$ <div style="border: 1px solid black; padding: 2px; display: inline-block;"> $P_a = 77.8 \text{ k}$ </div>

✓ gcm

EXCLUSIVE: Just in Edutruth only

PROB #9-27

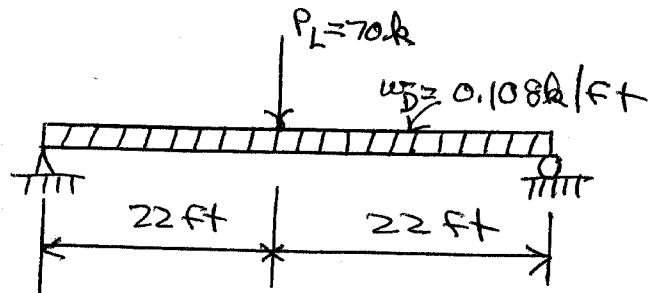


LRFD	ASD
$w_u = (1.2)(1.2) = 1.44 \text{ k/ft}$ $P_u = 1.6 P_L$ $M_u = \frac{(1.44)(40)^2}{8} + \frac{(1.6 P_L)(40)}{4}$ $= 288 + 16 P_L$ Noting $L_b > L_p < L_r$ and $C_b = 1.67$ $C_b \phi_b M_m = C_b [\phi_b M_{px} - BF(L_b - L_p)] \leq \phi_b M_{px}$ $= 1.67 [1170 - 33.3(20 - 7.42)]$ $= 1254.3 \text{ ft-k} > 1170 \text{ ft-k}$ $\therefore \text{Use } 1170 \text{ ft-k}$ $288 + 16 P_L = 1170$ $P_L = 55.12 \text{ k}$	$w_a = 1.2 \text{ k/ft}$ $P_a = P_L$ $M_u = \frac{(1.2)(40)^2}{8} + \frac{(P_L)(40)}{4}$ $= 240 + 10 P_L$ Noting $L_b > L_p < L_r$ and $C_b = 1.67$ $C_b \frac{M_m}{S_b} = C_b \left[\frac{M_{px}}{S_b} - BF(L_b - L_p) \right] \leq \frac{M_{px}}{S_b}$ $\frac{M_m}{S_b} = 1.67 [778 - 22.2(20 - 7.42)]$ $= 832.9 > \frac{M_{px}}{S_b} = 778 \text{ ft-k}$ $\therefore \text{Use } 778 \text{ ft-k}$ $240 + 10 P_L = 778$ $P_L = 53.8 \text{ k}$

✓ J.C.M.

EXCLUSIVE: Just in Edutruth only

PROB # 9-28



Assume beam $w_t = 108 \text{ lbs/ft}$

LRFD	ASD
$w_u = (1.2)(0.108) = 0.1296 \text{ k/ft}$ $P_u = (1.6)(70) = 112 \text{ k}$ $M_u = \frac{(0.1296)(44)^2}{8} + \frac{(112)(44)}{4}$ $= 1263.4 \text{ ft-k}$ $C_b = 1.67$ from Text Figure 9-10 Enter AISC Tables 3-10 with $M_{u \text{ effect.}} = \frac{1263.4}{1.67} = 756.5 \text{ ft-k}$ Try W24x104 ($\phi_b M_{px}$ from AISC Table 3-2 = 1080 ft-k $< 1263.4 \text{ ft-k}$ <u>N.G.</u> <div style="border: 1px solid black; padding: 5px; display: inline-block;"> USE W30x108 ($\phi_b M_{px} = 1300 \text{ ft-k}$) $> 1263.4 \text{ ft-k}$ </div>	$w_a = 0.108 \text{ k/ft}$ $P_a = 70 \text{ k}$ $M_a = \frac{(0.108)(44)^2}{8} + \frac{(70)(44)}{4}$ $= 796.14 \text{ ft-k}$ $C_b = 1.67$ from Text Figure 9-10 Enter AISC Tables 3-10 with $M_{a \text{ effect.}} = \frac{796.14}{1.67} = 476.74 \text{ ft-k}$ Try W21x101 ($\frac{M_{px}}{\Omega_b} = 631 \text{ ft-k}$) $< 796.14 \text{ ft-k}$ <u>N.G.</u> <div style="border: 1px solid black; padding: 5px; display: inline-block;"> USE W30x108 ($\frac{M_{px}}{\Omega_b}$) $= 863 \text{ ft-k} > 796 \text{ ft-k}$ </div>

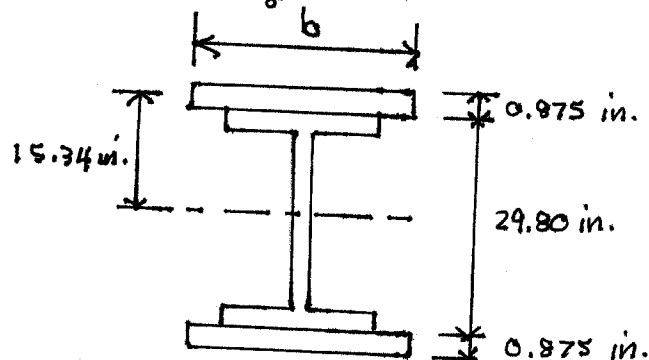
✓ JCM

EXCLUSIVE: Just in Edutruth only

PROB # 9-29

Designated section is a W30 x 148 ($Z_x = 500 \text{ in}^3$)

But section is not available. On hand, however, is a W30 x 108 ($Z = 346 \text{ in}^3$, $d = 29.8 \text{ in.}$) together with some $\frac{7}{8} \text{ in.}$ PLS



$$Z_{\text{Reqd}} = 500 = 346 + (Z) \left(\frac{7}{8} \times 6 \right) (15.34)$$

$$b = 5.74 \text{ in.} \quad \text{Say } \underline{\underline{6 \text{ in.}}}$$

USE 1 PL $\frac{7}{8} \times 6$ EACH FLANGE

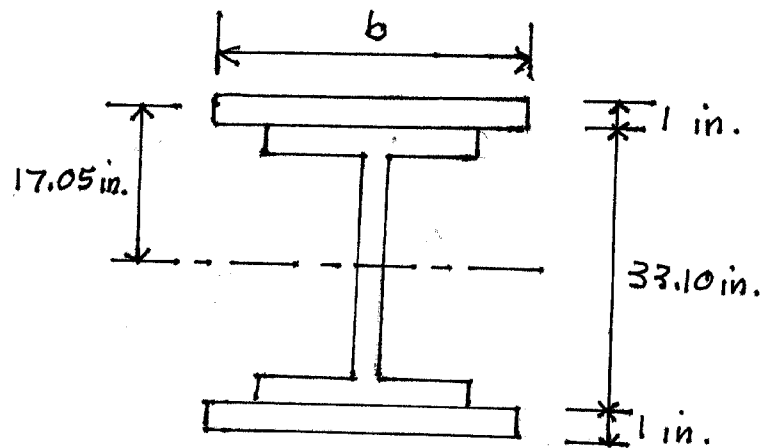
✓ JCM

EXCLUSIVE: Just in Edutruth only

PROB# 9-30

Original beam was to be W33x152 ($Z_x = 559 \text{ in}^3$)

But the section shipped was
a W33x130 ($Z_x = 467 \text{ in}^3$, $d = 33.1 \text{ in.}$). Available
are 1 in. plates.



$$Z_{\text{Reqd}} = 559 = 467 + (2)(1 \times b)(17.05)$$

$$b = 2.70 \text{ in.}$$

USE 1 PL 1 X 3 EACH FLANGE

✓ g < m_c

EXCLUSIVE: Just in Edutruth only

PROB # 9-31

Original beam was a W33X152 ($Z_x = 559 \text{ in}^3$, $F_y = 65 \text{ ksi}$)

$$M_m = M_p = \frac{F_y Z}{12} = \frac{(65)(559)}{12} = 3028$$

Section shipped was a W33X130 ($Z_x = 467 \text{ in}^3$, $F_y = 50 \text{ ksi}$, $d = 33.1 \text{ in.}$)

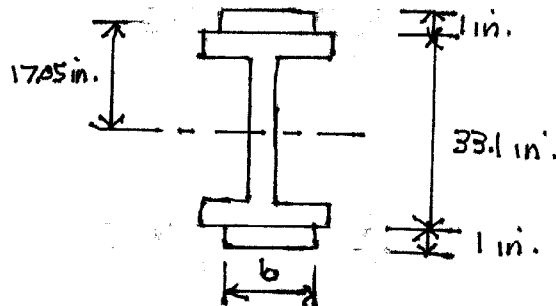
$$M_m = M_p \text{ of W33X130} = \frac{F_y Z}{12} = \frac{(50)(467)}{12} = 1946 \text{ ft-k}$$

$$\text{Additional } M_m \text{ needed} = 3028 - 1946 = 1082 \text{ ft-k}$$

$\frac{F_y Z}{12}$ for cover plates must equal 1082 ft-k

$$Z \text{ of PLS} = \frac{(12)(1082)}{50} = 259.68 \text{ in}^3$$

Assume 1 in. thick plates



$$(1b)(17.05)(2) = 259.68$$

$$b = 7.62 \text{ in.}$$

USE 1X8 PLS ($F_y = 50 \text{ ksi}$)

Checking

$$Z = 467 + (1 \times 8)(17.05)(2) = 739.8 \text{ in}^3$$

$$M_m = M_p = \frac{(50)(739.8)}{12} = 3082 \text{ ft-k} > 3028 \text{ ft-k} \quad \underline{\text{OK}}$$

✓ JC MC

EXCLUSIVE: Just in Edutruth only

PROB # 9-32

$$M_u = \frac{(15)(22)^2}{8} = 907.5 \text{ ft-lb}$$

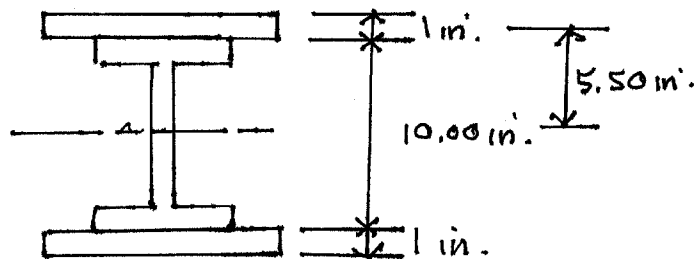
$$\max d = 12.00 \text{ in.}$$

$$Z_{Reqd} = \frac{(12)(907.5)}{(0.9)(50)} = 242 \text{ in.}^3$$

Many possible solutions are available

Try W10x49 ($d=10.0$ in., $Z_x=60.4$ in.³, $b_f=10.00$ in.)

Try 1-in. thick PLS



$$Z_{\text{needed}} = 242 - 60.4 = 181.6 \text{ in.}^3 \text{ from PLS}$$

$$181.6 = (2)(1)(6)(5.5)$$

$$b \approx 16.5 \text{ in.}$$

USE 1X17 PLS

Checking

$$Z = 60.4 + (17)(2)(5.5) = 247.4 \text{ in.}^3 > 242 \text{ in.}^3$$

$$\phi M_m = \frac{(0.9)(50)(247.4)}{12} = 927.7 \text{ ft-k} > 907.5 \text{ ft-k}$$

$$\sqrt{g} \, c \, m^2$$

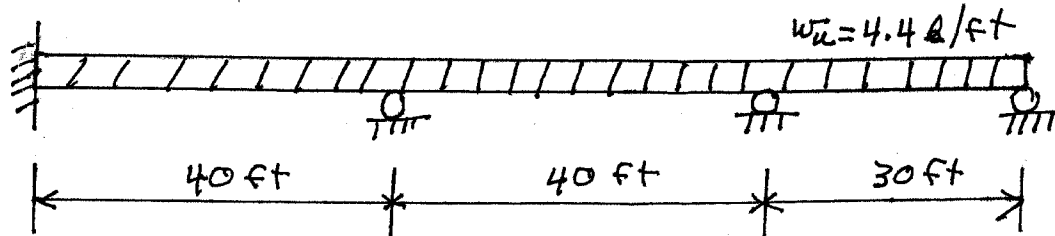
223

EXCLUSIVE: Just in Edutruth only

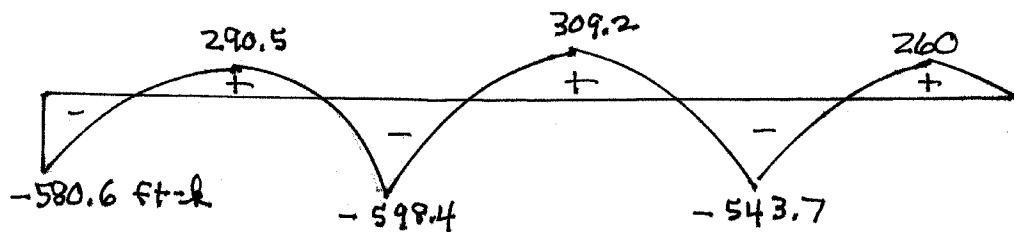
CHAPTER 10

PROB #10-1

$$w_u = (1.2)(1.0) + (1.6)(2.0) = 4.4 \text{ k/ft}$$



Analysis made with moment distribution



Maximum negative moment for design

$$= (0.9)(-598.4) = -538.6 \text{ ft-k} \leftarrow$$

Maximum positive for design

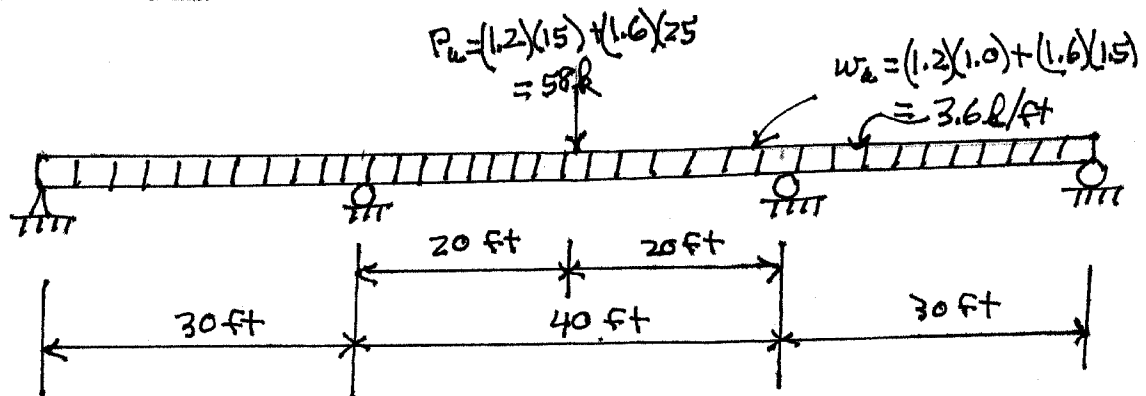
$$= 309.2 + \left(\frac{1}{10}\right)\left(\frac{598.4 + 543.7}{2}\right) = +366.3 \text{ ft-k}$$

USE W21X62 (from AISC Table 3-2)

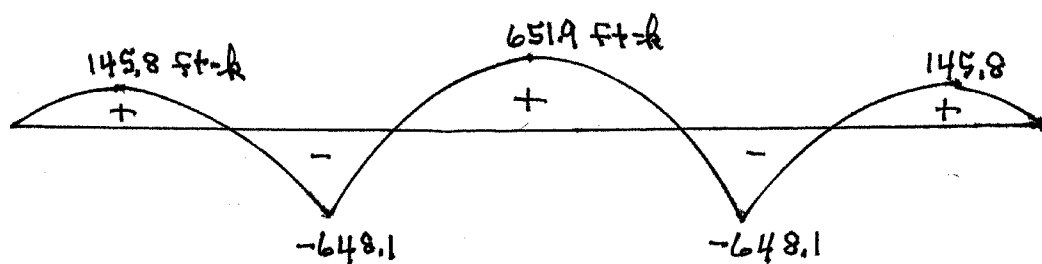
VGCM

EXCLUSIVE: Just in Edutruth only

PROB #10-2



Analysis made with moment distribution



Max $M = +651.9 \text{ ft-k}$

USE W24 X 68 (AISC Table 3-2)

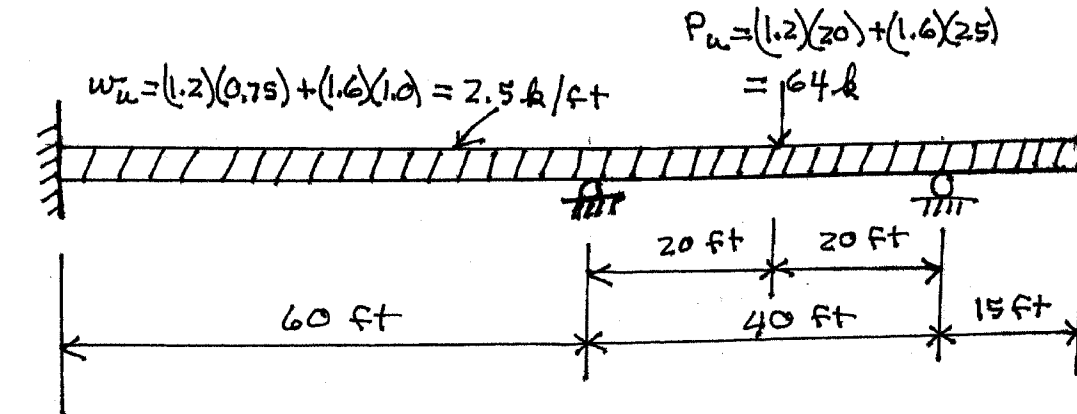
$\checkmark gcm \equiv$

225

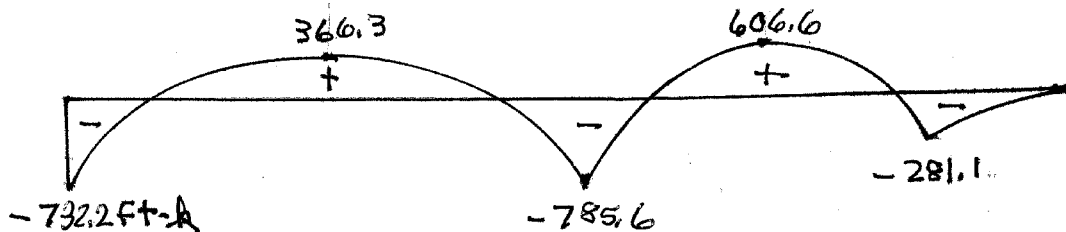
EXCLUSIVE: Just in Edutruth only <http://edutruth.4shared.com>

EXCLUSIVE: Just in Edutruth only

PROB # 10-3



Analysis made with moment distribution



Maximum Negative moment for design
 $= (0.9)(-785.6) = -707 \text{ ft-k} \leftarrow$

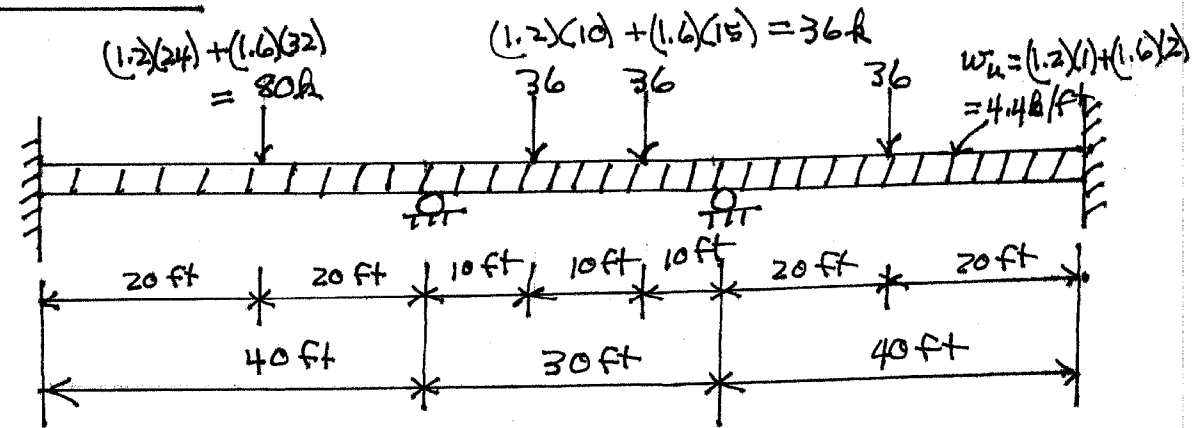
Maximum Positive moment for design
 $= 606.6 + \left(\frac{1}{10}\right)\left(\frac{785.6 + 281.1}{2}\right) = 659.9 \text{ ft-k}$

USE W24X76 (AISC Table 3-2)

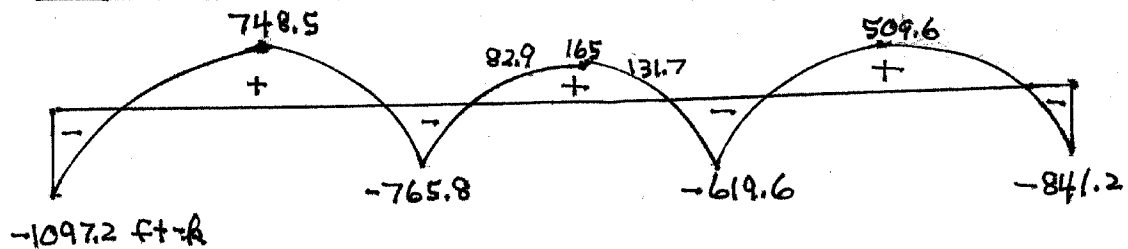
✓ gcm

EXCLUSIVE: Just in Edutruth only

PROB #10-4



Analysis made with moment distribution



Maximum Negative moment for design
 $= (0.90)(-1097.2) = -987.5 \text{ ft-k} \leftarrow$

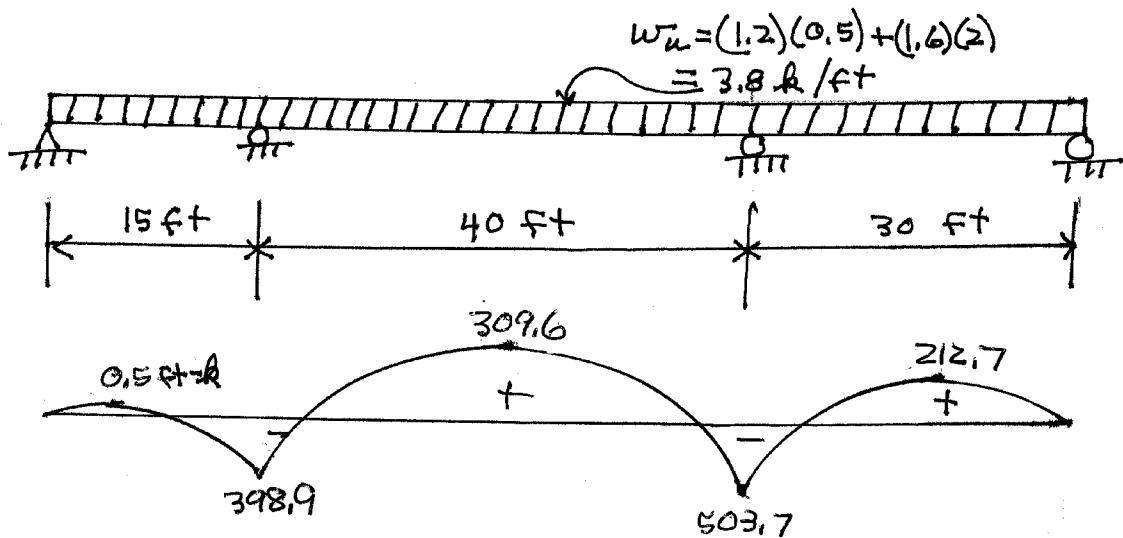
Maximum Positive moment for design
 $= 748.5 + \left(\frac{1}{10}\right) \left(\frac{1097.2 + 765.8}{2}\right) = +841.6 \text{ ft-k}$

USE W30 X90 (from AISC Table 3-2)

OK MC

EXCLUSIVE: Just in Edutruth only

PROB#10-5



Max. neg. moment for design = $(0.9)(-503.7) = -453.3 \text{ k}$

Max. pos. moment for design = $309.6 + \frac{1}{10} \left(\frac{398.9 + 503.7}{2} \right)$

= +354.7 ft-k

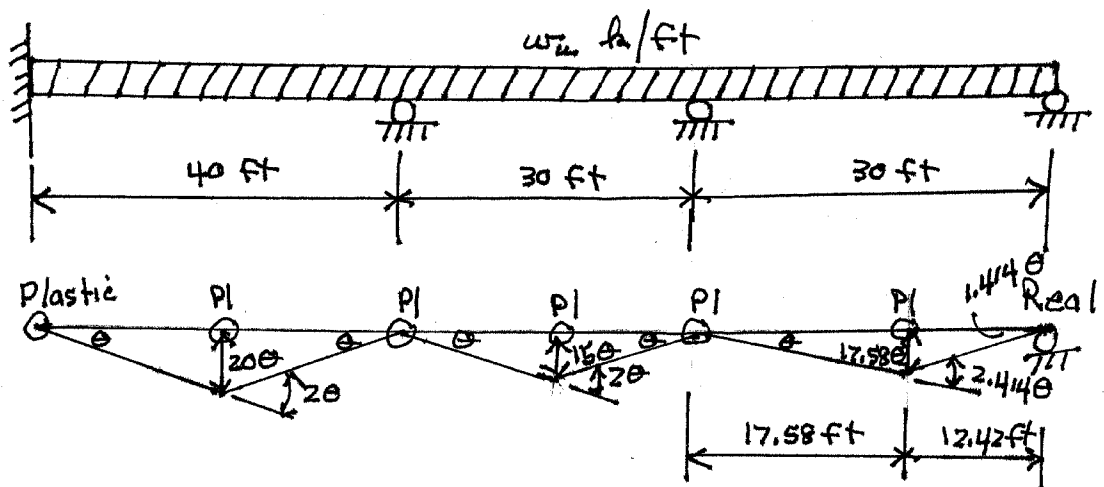
USE W21x55 (from AISC Table 3-2)

✓ g.c.m.e

EXCLUSIVE: Just in Edutruth only

PROB #10-6

LRFD	ASD
$w_u = (1.2)(1.0) + (1.6)(2) = 4.4 \text{ k/ft}$	$w_d = 1.0 + 2.0 = 3.0 \text{ k/ft}$



$$\begin{aligned}
 M_m(40) &= (40 w_u) \left(\frac{1}{2} \times 20 \right) & M_m(40) &= 30 w_u \left(\frac{1}{2} \times 15 \right) & M_m(3.4140) &= (30 w_u) \left(\frac{1}{2} \times 17.58 \right) \\
 M_m &= (100)(4.4) & M_m &= 56.25 w_u & M_m &= 77.24 w_u \\
 &= 440 \text{ ft-k} & &= 247.5 \text{ ft-k} & &= 339 \text{ ft-k}
 \end{aligned}$$

Try W21 X 55 ($Z_x = 126 \text{ in}^3$)

$$M_m = F_y Z = \frac{(50)(126)}{12} = 525 \text{ ft-k}$$

LRFD $\phi_b = 0.90$	ASD $\Omega_b = 1.67$
$\phi_b M_m = (0.90)(525) = 472.5 \text{ ft-k}$	$\frac{M_m}{\Omega_b} = \frac{525}{1.67} = 314.4 \text{ ft-k}$

✓ JCMC

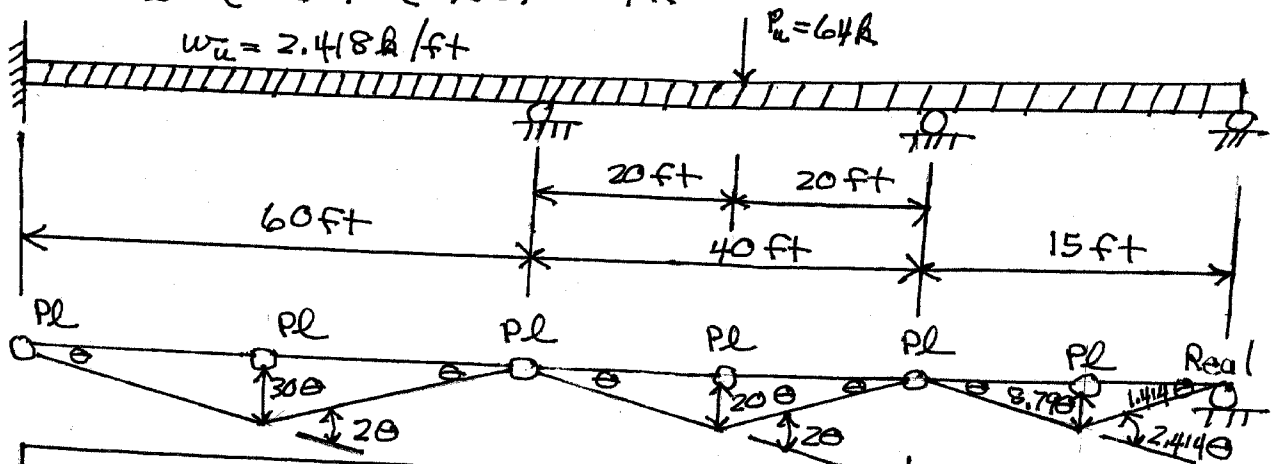
EXCLUSIVE: Just in Edutruth only

PROB# 10-7

Assume beam wt = 68 lbs/ft

$$w_u = (1.2)(0.75 + 0.068) + (1.6)(1.0) = 2.58 \text{ k/ft}$$

$$P_u = (1.2)(20) + (1.6)(25) = 64 \text{ k}$$

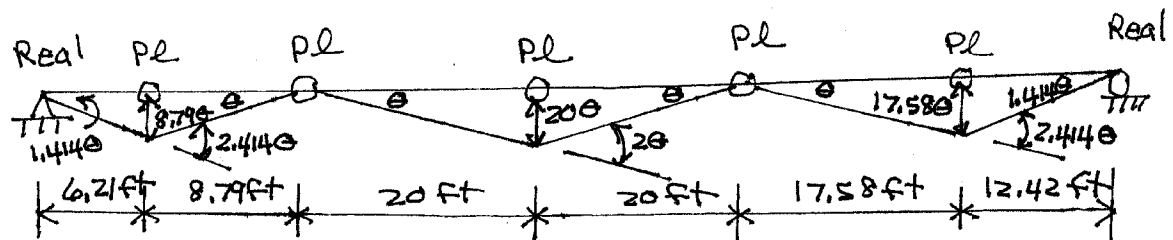
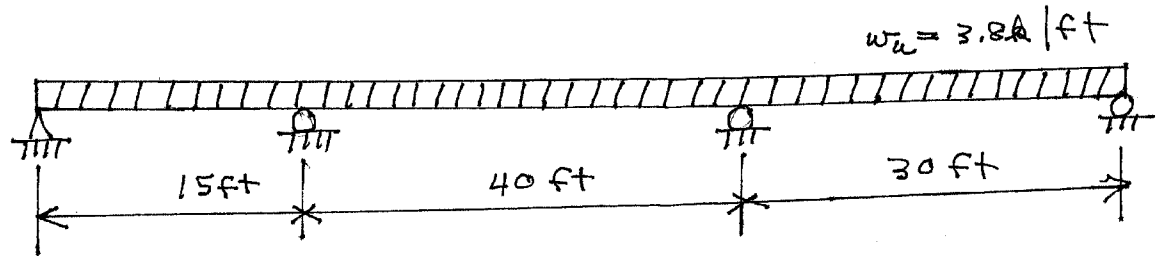


$M_m(4\theta) = (60w_u)\left(\frac{1}{2} \times 30\theta\right)$ $M_m = 225w_u$ $= (225)(2.58)$ $= 580.5 \text{ ft-k} \leftarrow$ <p><u>USE W21 X 68</u></p>	$M_m(4\theta) = (40w_u)\left(\frac{1}{2} \times 20\theta\right) + (P_u)(20\theta)$ $M_m = 100w_u + 5P_u$ $= (100)(2.58) + (5)(64)$ $= 578 \text{ ft-k}$	$M_m(3.414\theta) = (15w_u)\left(\frac{1}{2} \times 8.79\theta\right)$ $M_m = 19.3w_u$ $= (19.3)(2.58)$ $= 49.8 \text{ ft-k}$
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$r_g < m \leq$

EXCLUSIVE: Just in Edutruth only

PROB #10-8



$$M_u(0 + 2.4140) = (15)(3.8)(\frac{1}{2} \times 8.790)$$

$$M_u = 73.4 \text{ ft-k}$$

$$(M_u)(40) = (40)(3.8)(\frac{1}{2} \times 200)$$

$$M_u = 380 \text{ ft-k} \leftarrow$$

$$M_u(3.4440) = (30)(3.8)(\frac{1}{2} \times 17.580)$$

$$M_u = 293.5 \text{ ft-k}$$

From AISC Table 3-2

USE W21X48

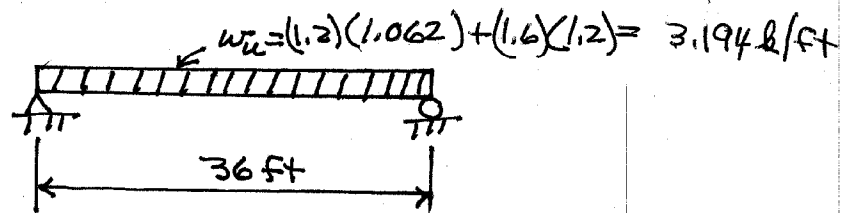
✓ ϕM_n

EXCLUSIVE: Just in Edutruth only

PROB# 10-9

Assume beam wt = 62 lbs/ft

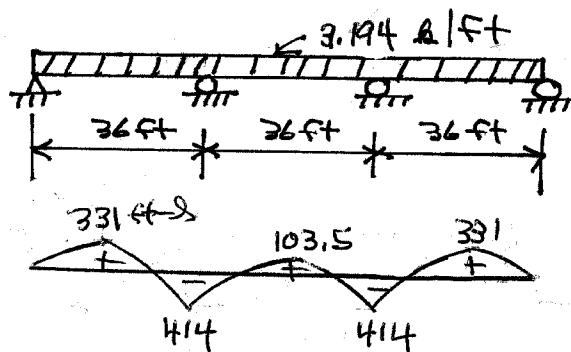
(a) Using simple spans



$$M_u = \frac{(3.194)(36)^2}{8} = 517.4 \text{ ft-k}$$

USE W21X62

(b) Using continuous span



Max neg M for design = $(0.9)(414) = 372.6 \text{ ft-k} \leftarrow$

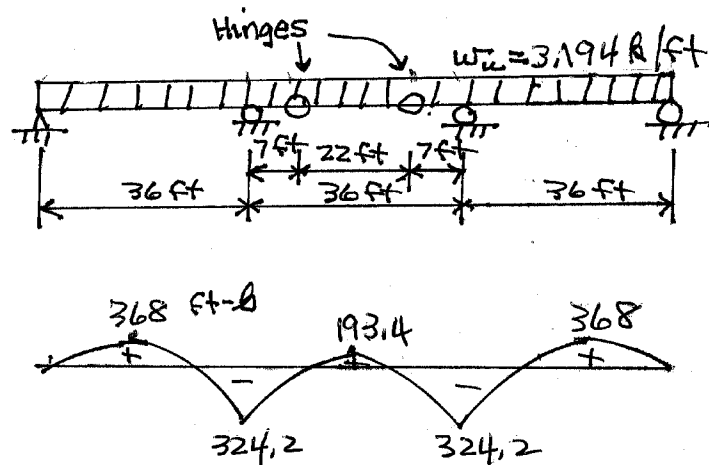
Max pos M for design = $331 + \frac{1}{10} \left(\frac{0 + 414}{2} \right) = 351.7 \text{ ft-k}$

USE W21X48

EXCLUSIVE: Just in Edutruth only

PROB#10-9 CONTD.

(c) Using a cantilever structure



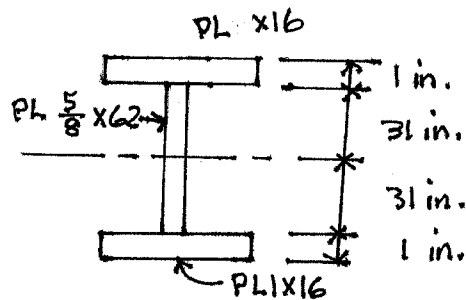
Max $M_u = 368 \text{ ft-k}$

USE W21 X48

✓ 9 cm

EXCLUSIVE: Just in Edutruth only

PROB # 10-10



Moment Strengths

LRFD $\phi_b = 0.90$	ASD $\Omega_b = 1.67$
$Z_x = (2)(16)(31.5) + (2)(\frac{5}{8})(31)(\frac{31}{2})$ $= 1608.8 \text{ in}^3$ $M_m = F_y Z = \frac{(50)(1608.8)}{12}$ $= 6703 \text{ ft-k}$ $\phi_b M_m = (0.90)(6703) = 6033 \text{ ft-k}$	$Z_x = 1608.8 \text{ in}^3$ $M_m = 6703 \text{ ft-k}$ $\frac{M_m}{\Omega_b} = \frac{6703}{1.67} = 4014 \text{ ft-k}$

Shear strengths

$k_v = 5$ as web is unstiffened

$$\frac{h}{t_w} = \frac{62}{0.625} = 99.2 < 260 > 1.37 \sqrt{\frac{A_v E}{F_y}}$$

$$= 1.37 \sqrt{\frac{(5)(29 \times 10^3)}{50}} = 73.78$$

$$\therefore C_v = \frac{1.51 E A_v}{(\frac{h}{t_w})^2 (F_y)} = \frac{(1.51)(29 \times 10^3)(5)}{(99.2)^2 (50)} = 0.445$$

$$V_m = 0.6 F_y A_w C_v = (0.6)(50)(64 \times \frac{5}{8})(0.445) = 534 \text{ k}$$

LRFD $\phi_v = 0.90$	ASD $\Omega_v = 1.67$
$\phi_v V_m = (0.90)(534) = 480.6 \text{ k}$	$\frac{V_m}{\Omega_v} = \frac{534}{1.67} = 319.8 \text{ k}$

ANSWERS

$$\phi_b M_m = 6033 \text{ ft-k}$$

$$\phi_v V_m = 480.6 \text{ k}$$

$$\frac{M_m}{\Omega_b} = 4014 \text{ ft-k}$$

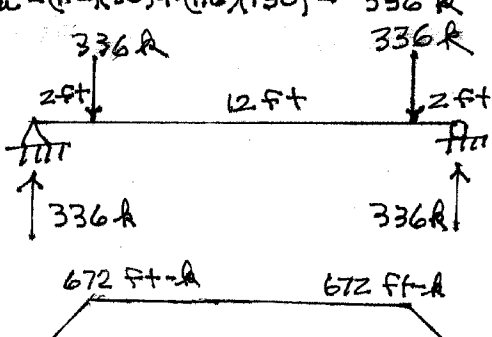
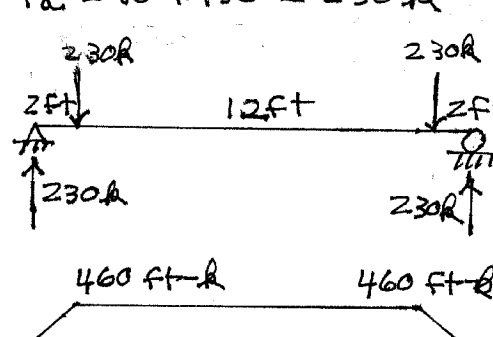
$$\frac{V_m}{\Omega_v} = 319.8 \text{ k}$$

234

1928m

EXCLUSIVE: Just in Edutruth only

PROB #10-11

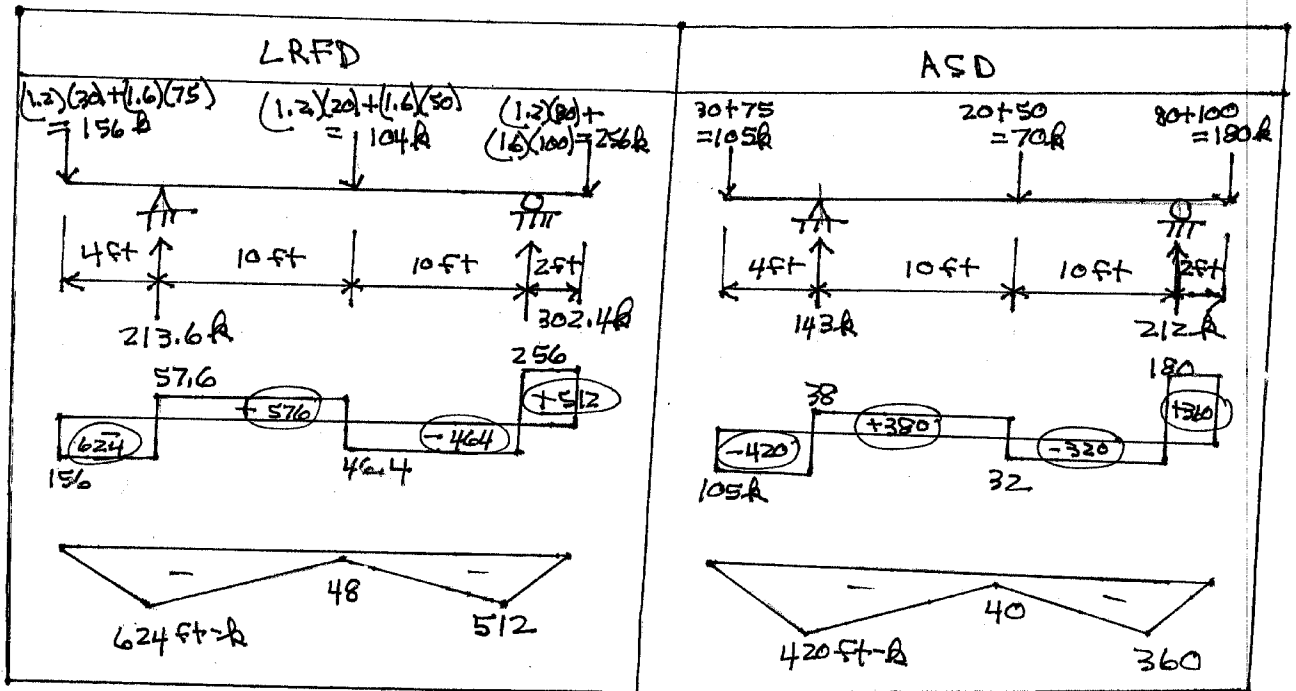
LRFD	ASD
$P_u = (1.2)(80) + (1.6)(150) = 336 \text{ k}$ 	$P_a = 80 + 150 = 230 \text{ k}$ 
<p>From AISC Table 3-2</p> <p>W24x76 needed for M_u of 672 ft-k</p> <p>But $\phi_v V_m = 316 \text{ k}$ $< 336 \text{ k}$ <u>N.G.</u></p> <p>Try W24x84</p> <p>$\phi_b M_m = 840 \text{ ft-k} > 672 \text{ ft-k}$</p> <p>$\phi_v V_m = 340 \text{ k} > 336 \text{ k}$</p> <p>USE W24x84</p>	<p>From AISC Table 3-2</p> <p>W24x76 needed for M_u of 460 ft-k</p> <p>But $\phi_v V_m = 210 \text{ k}$ $< 230 \text{ k}$ <u>N.G.</u></p> <p>Try W24x84</p> <p>$\frac{M_m}{\phi_b} = 559 \text{ k} > 460 \text{ ft-k}$</p> <p>$\frac{V_m}{\phi_v} = 227 \text{ k} < 230 \text{ k}$</p> <p>USE W27x84</p>

✓ $\phi < M^C$

235

EXCLUSIVE: Just in Edutruth only

PROB # 10-12



For moment Try W24 x 68

LRFD	ASD
$\phi_b M_{px} = 664 \text{ ft-k} > 624 \text{ ft-k} \quad \underline{\text{OK}}$	$\frac{M_{max}}{\phi_b} = 442 \text{ ft-k} > 420 \text{ ft-k} \quad \underline{\text{OK}}$
$\phi_v V_{nx} = 295 \text{ k} > 256 \text{ ft-k} \quad \underline{\text{OK}}$	$\frac{V_{max}}{\phi_v} = 197 \text{ k} > 180 \text{ k} \quad \underline{\text{OK}}$

USE W24 x 68 FOR BOTH LRFD AND ASD

✓ $J C M =$

EXCLUSIVE: Just in Edutruth only

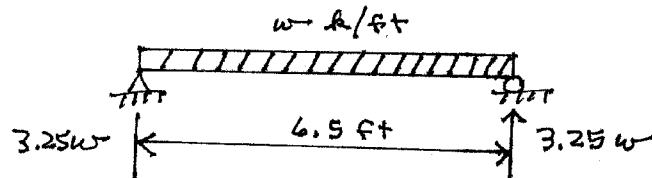
PROB# 10-13

LRFD	ASD
<p>$P_u = (1.2)(80) + (1.6)(150) = 336 \text{ k}$</p> <p style="text-align: center;">6 ft 12 ft 6 ft</p> <p style="text-align: center;">6 ft 6 ft</p> <p>Design for moment</p> $Z_{\text{Reqd}} = \frac{(1.2)(672)}{(0.9)(36)} = 248.9 \text{ in}^3$ <p>Try W 30 x 90 ($Z_x = 283 \text{ in}^3$, $d = 29.5 \text{ in}$, $t_w = 0.470 \text{ in}$, $A = 1.26 \text{ in}^2$)</p> $\frac{h}{t_w} = \frac{29.5 - (2)(1.26)}{0.470} = 57.4$ $< 2.24 \sqrt{\frac{29 \times 10^3}{36}} = 63.6$ $V_n = (0.6)(36)(29.5)(0.470)(1.0) = 299.5 \text{ k}$ $\phi V_n = (1.0)(299.5) = 299.5 < 336 \text{ k}$ <p>Try W 30 x 108 ($d = 31.7 \text{ in}$, $t_w = 0.545 \text{ in}$, $A = 1.41 \text{ in}^2$)</p> $\frac{h}{t_w} = \frac{31.7 - (2)(1.41)}{0.545} = 52.99 < 63.6$ $V_n = (0.6)(36)(31.7)(0.545)(1.0) = 373.2 \text{ k}$ $\phi V_n = (1.0)(373.2) > 336 \text{ k} \quad \text{OK}$ <div style="border: 1px solid black; padding: 5px; width: fit-content; margin: 0 auto;">USE W 30 x 108</div>	<p>$P_a = 80 + 150 = 230 \text{ k}$</p> <p style="text-align: center;">6 ft 12 ft 6 ft</p> <p style="text-align: center;">6 ft 6 ft</p> <p>Design for moment</p> $Z_{\text{Reqd}} = \frac{(1.67)(12)(460)}{36} = 256.1 \text{ in}^3$ <p>Try W 30 x 90</p> <div style="border: 1px solid black; border-radius: 50%; padding: 20px; text-align: center; margin: 20px auto; width: 80%;"> <p>Same calculations as for LRFD</p> </div> $\frac{V_n}{\Omega} = \frac{373.2}{1.50} = 248.8 \text{ k} > 230 \text{ k}$ <div style="border: 1px solid black; padding: 5px; width: fit-content; margin: 0 auto;">USE W 30 x 108</div>

EXCLUSIVE: Just in Edutruth only

PROB # 10-14

Using a W21x93



For Moment Using AISC Table 3-2

LRFD	ASD
$\phi_b M_m = 829 \text{ ft-k}$	$\frac{M_m}{\Omega_b} = 551 \text{ k}$
$\frac{w_u L^2}{8} = 829$	$\frac{w_a L^2}{8} = 551$
$w_u = \frac{(8)(829)}{(6.5)^2} = 156.97 \text{ k/ft}$	$w_a = \frac{(8)(551)}{(6.5)^2} = 104.331 \text{ k/ft}$
$-1.2 \text{ BM wt} = -(1.2)(0.093) = -0.11$	$-1.2 \text{ BM wt} = -0.093$
Net $w_u = 156.86 \text{ k/ft}$	Net $w_a = 104.24 \text{ k/ft}$

For Shear Using AISC Table 3-2

LRFD	ASD
$\phi_v V_{mx} = 376 \text{ k}$	$\frac{V_m}{\Omega_v} = 251 \text{ k}$
$\frac{w_u L}{2} = 376$	$\frac{w_a L}{2} = 251$
$w_u = \frac{(2)(376)}{6.5} = 115.69 \text{ k/ft}$	$w_a = \frac{(2)(251)}{6.5} = 77.23 \text{ k/ft}$
$-1.2 \text{ BM wt} = -(1.2)(0.093) = -0.11$	$-1.2 \text{ BM wt} = -0.093$
Net $w_u = 115.58 \text{ k/ft}$	Net $w_a = 77.14 \text{ k/ft}$

ANSWER.

$$w_u = 115.58 \text{ k/ft}$$

$$w_a = 77.14 \text{ k/ft}$$

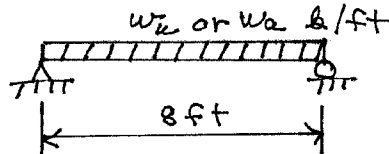
✓ JCM

EXCLUSIVE: Just in Edutruth only

PROB#10-15

using a W14 X 38

Values for shear and moment taken from AISC Table 3-2



For Moment Using AISC Table 3-2

LRFD	ASD
$\phi_b M_m = 231 \text{ ft-k}$ $\frac{w_u L^2}{8} = 231$ $w_u = \frac{(8)(231)}{(8)^2} = 28.875 \text{ k/ft}$ $-1.2 \text{ Bm wt} = \frac{(1.2)(0.038)}{(8)^2} = -0.0046$ $\text{Net } w_u = 28.83 \text{ k/ft}$	$\frac{M_m}{\Omega_b} = 153 \text{ ft-k}$ $\frac{w_a L^2}{8} = 153$ $w_a = \frac{(8)(153)}{(8)^2} = 19.125 \text{ k/ft}$ $-\text{Bm wt} = \frac{(0.038)}{(8)^2} = -0.0038$ $\text{Net } w_a = 19.087 \text{ k/ft}$

For Shear Using AISC Table 3-2

LRFD	ASD
$\phi_v V_m = 131 \text{ k}$ $\frac{w_u L}{2} = 131$ $w_u = \frac{(2)(131)}{8} = 32.75 \text{ k/ft}$ $-1.2 \text{ Bm wt} = \frac{(1.2)(0.038)}{(8)^2} = -0.0046$ $\text{Net } w_u = 32.70 \text{ k/ft}$	$\frac{V_{mx}}{\Omega_v} = 87.4 \text{ k}$ $\frac{w_a L}{2} = 87.4$ $w_a = \frac{(2)(87.4)}{8} = 21.85 \text{ k/ft}$ $-\text{Bm wt} = \frac{(0.038)}{(8)^2} = -0.0038$ $\text{Net } w_a = 21.81 \text{ k/ft}$

ANSWER.

$$w_u = 28.83 \text{ k/ft}$$

$$w_a = 19.09 \text{ k/ft}$$

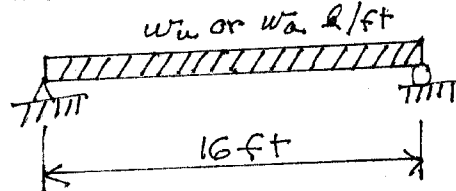
✓ JCMC

EXCLUSIVE: Just in Edutruth only

PROB # 10-16

Using a W36x150

Values for shear and moment taken from AISC Table 3-2



For Moment using AISC Table 3-2

LRFD	ASD
$\phi_b M_m = 2180 \text{ ft-k}$	$\frac{M_m}{\phi_b} = 1450 \text{ ft-k}$
$\frac{w_u L^2}{8} = 2180$	$\frac{w_a L^2}{8} = 1450$
$w_u = \frac{(8)(2180)}{(16)^2} = 68.12 \text{ k/ft}$	$w_a = \frac{(8)(1450)}{(16)^2} = 45.31 \text{ k/ft}$
$-1.2 \text{ Bm wt} = -1.2(0.15) = -0.18$	$- \text{Bm wt} = -0.15$
Net $w_u = 67.94 \text{ k/ft}$	Net $w_a = 45.16 \text{ k/ft}$

For Shear using AISC Table 3-2

LRFD	ASD
$\phi_v V_m = 672 \text{ k}$	$\frac{V_m}{\phi_v} = 448 \text{ k}$
$\frac{w_u L}{2} = 672$	$\frac{w_a L}{2} = 448$
$w_u = \frac{(2)(672)}{16} = 84.00 \text{ k/ft}$	$w_a = \frac{(2)(448)}{16} = 56.00 \text{ k/ft}$
$-1.2 \text{ Bm wt} = -(1.2)(0.15) = -0.18$	$- \text{Bm wt} = -0.15$
Net $w_u = 83.82 \text{ k/ft}$	Net $w_a = 55.85 \text{ k/ft}$

ANSWER.

$$w_u = 67.94 \text{ k/ft}$$

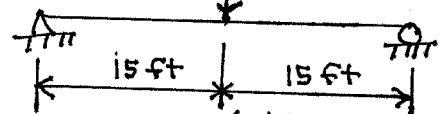
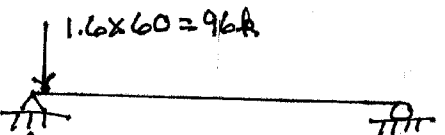
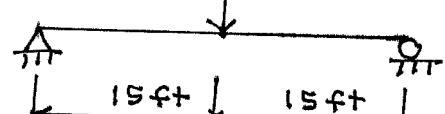

$$w_a = 45.16 \text{ k/ft}$$

✓ JCMC

240

EXCLUSIVE: Just in Edutruth only

PROB # 10-17

LRFD	ASD
<p>Neglecting beam wt</p> <p>$1.6 \times 60 = 96 \text{ k}$</p>  <p>Max $M_u = \frac{(96)(30)}{4} = 720 \text{ ft-k}$</p> <p>$1.6 \times 60 = 96 \text{ k}$</p>  <p>Max $V_u = 96 \text{ k}$</p>	<p>Neglecting beam wt</p> <p>60 k</p>  <p>Max $M_a = \frac{(60)(30)}{4} = 450 \text{ ft-k}$</p> <p>$60 \text{ k}$</p>  <p>Max $V_a = 60 \text{ k}$</p>

From AISC Table 3-2

Try W24X76

LRFD	ASD
<p>$\phi_b M_m = 750 \text{ ft-k} > 720 \text{ ft-k} \quad \text{OK}$</p> <p>$\phi_v V_m = 316 \text{ k} > 96 \text{ k} \quad \text{OK}$</p>	<p>$\frac{M_m}{\Omega_b} = 499 \text{ ft-k} > 450 \text{ ft-k} \quad \text{OK}$</p> <p>$\frac{V_m}{\Omega_v} = 210 \text{ k} > 60 \text{ k} \quad \text{OK}$</p>

ANSWER.

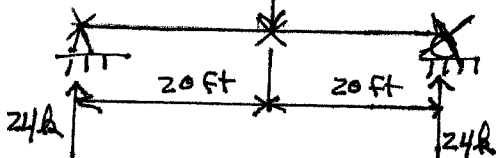
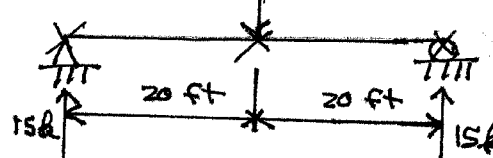
W24X76

W24X76

$\checkmark \phi < \phi_c$

EXCLUSIVE: Just in Edutruth only

PROB# 10-18

LRFD	ASD
 <p> $P_u = 1.6(30) = 48 \text{ k}$ $\text{Max } M_u = \frac{(48)(40)}{4} = 480 \text{ ft-k}$ $\text{Max } V_u = 24 \text{ k}$ $L_{unbr.} = 20 \text{ ft}$ </p>	 <p> $P_a = 30 \text{ k}$ $\text{Max } M_a = \frac{(30)(40)}{4} = 300 \text{ ft-k}$ $\text{Max } V_a = 15 \text{ k}$ $L_{unbr.} = 20 \text{ ft}$ </p>
<p><u>Check Deflection</u></p> <p> $\text{Max. permissible } \Delta = \left(\frac{1}{1000}\right)(12 \times 40) = 0.48 \text{ in.}$ $\text{Calc. } \Delta = \frac{(300)(40)^2}{(201)(640)} = 3.7314 \text{ in.}$ $> 0.48 \text{ in.}$ $\text{Min. } I_x = \left(\frac{3.7314}{0.48}\right)(640)$ $= 4975 \text{ in.}^4$ <u>From AISC Table 3-3</u> <div style="border: 1px solid black; padding: 2px; display: inline-block;">USE W33X118</div> </p>	<p><u>Check Deflection</u></p> <p> $\text{Max permissible } \Delta = \left(\frac{1}{1000}\right)(12 \times 40) = 0.48 \text{ in.}$ $\text{Calc. } \Delta = \frac{(300)(40)^2}{(201)(640)} = 3.7314 \text{ in.}$ $> 0.48 \text{ in.}$ $\text{Min. } I_x = \left(\frac{3.7314}{0.48}\right)(640)$ $= 4975 \text{ in.}^4$ <u>From AISC Table 3-3</u> <div style="border: 1px solid black; padding: 2px; display: inline-block;">USE W33X118</div> </p>

vgcm

EXCLUSIVE: Just in Edutruth only

PROB # 10-19

LRFD	ASD
$w_u = (1.2)(1.20) + (1.6)(2.8) = 5.92 \text{ k/ft}$	$w_a = 1.20 + 2.8 = 4.00 \text{ k/ft}$
$M_u = \frac{(5.92)(24)^2}{8} = 426.24 \text{ ft-k}$	$M_a = \frac{(4.00)(24)^2}{8} = 288 \text{ ft-k}$
$V_u = (1.2)(5.92) = 7.104 \text{ k}$	$V_a = (1.2)(4.00) = 4.8 \text{ k}$

From AISC Table 3-2

Try W21x55 ($I_x = 1140 \text{ in}^4$)

LRFD	ASD
$\phi_b M_m = 473 \text{ ft-k} > 426.24 \text{ ft-k}$	$\frac{M_m}{\Omega_b} = 314 \text{ ft-k} > 288 \text{ ft-k}$
$\phi_v V_m = 234 \text{ k} > 7.104 \text{ k}$	$\frac{V_m}{\Omega_v} = 156 \text{ k} > 4.8 \text{ k}$

Check Service load deflection ($\text{Max } \Delta = \frac{12 \times 24}{1200} = 0.24 \text{ in.}$)

$$\Delta = \frac{m L^2}{C_1 I_x} = \frac{(288)(24)^2}{(161)(1140)} = 0.904 \text{ in.} > 0.24 \text{ in.}$$

$$\text{Min } I_x = \left(\frac{0.904}{0.24} \right) (1140) = 4294 \text{ in}^4$$

USE W30x108 for both LRFD and ASD

✓ JCMC

EXCLUSIVE: Just in Edutruth only

PROB #10-20

Assume beam $w_t = 230 \text{ lbs/ft}$

LRFD	ASD
$w_u = (1.2)(2.23) + (1.6)(4) = 9.076 \text{ k/ft}$	$w_a = 2.23 + 4 = 6.23 \text{ k/ft}$
$M_u = \frac{(9.076)(32)^2}{8} = 1161.7 \text{ ft-k}$	$M_a = \frac{(6.23)(32)^2}{8} = 797.44 \text{ ft-k}$
$V_u = (16)(9.076) = 145.2 \text{ k}$	$V_a = (16)(6.23) = 99.68 \text{ k}$

From AISC Table 3-2

Try W30x99 ($I_x = 3990 \text{ in.}^4$) Try W30x108 ($I_x = 4470 \text{ in.}^4$)

LRFD	ASD
$\phi_b M_u = 1170 \text{ ft-k} > 1161.7 \text{ ft-k}$	$\frac{M_u}{\phi_b} = 863 \text{ ft-k} > 797.44 \text{ ft-k}$
$\phi_v V_u = 463 \text{ k} > 145.2 \text{ k}$	$\frac{V_u}{\phi_v} = 325 \text{ k} > 99.68 \text{ k}$

Check service load deflection

$$\text{Max } \Delta = \left(\frac{1}{1600}\right)(12)(32) = 0.256 \text{ in.}$$

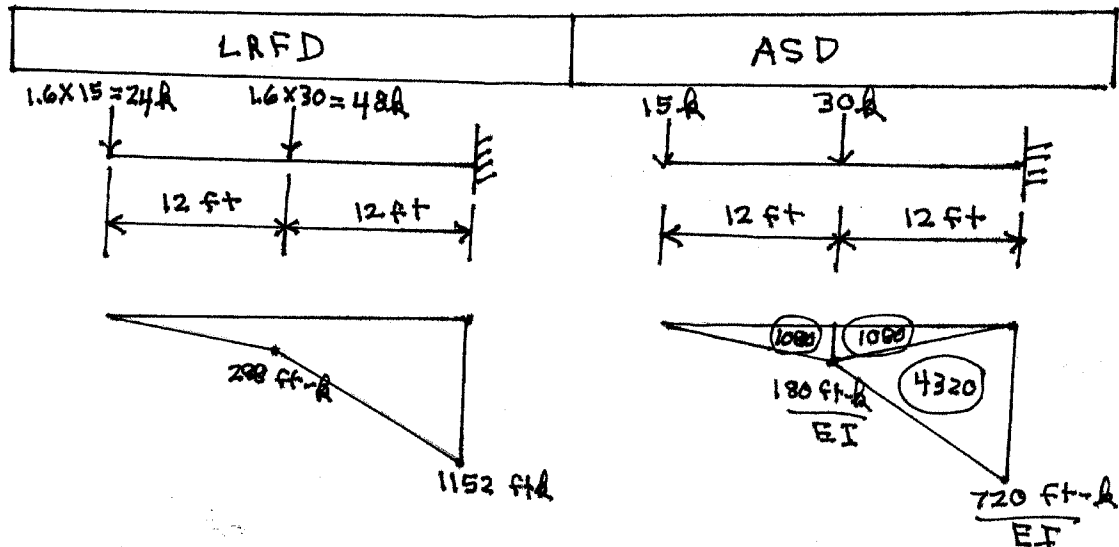
LRFD	ASD
$\Delta = \frac{ML^2}{8EI_x} = \frac{(797.44)(32)^2}{(161)(3990)}$ $= 1.271 \text{ in.} > 0.256 \text{ in.}$	$\Delta = \frac{ML^2}{8EI_x} = \frac{(797.44)(32)^2}{(161)(4470)}$ $= 1.135 \text{ in.} > 0.256 \text{ in.}$
$\text{Min. } I_x = \left(\frac{1.271}{0.256}\right)(3990)$ $= 19,810 \text{ in.}^4$	$\text{Min. } I_x = \frac{1.135}{0.256}(4470)$ $= 19,818 \text{ in.}^4$

ANSWER USE W44x230 For both LRFD and ASD

✓ JCM

EXCLUSIVE: Just in Edutruth only

PROB # 10-21

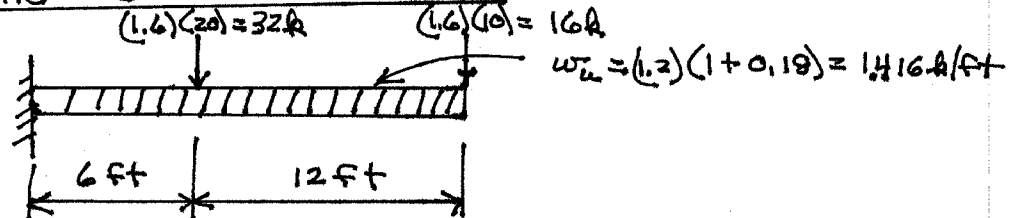


LRFD	ASD
<p>Max $M_u = 1152 \text{ ft-k}$ Max $V_u = 24 + 48 = 72k$ Using AISC Table 3-2 Try $W30 \times 99$ ($I_x = 3990 \text{ in}^4$) $\phi_b M_n = 1170 \text{ ft-k} > 1152 \text{ ft-k}$ $\phi_v V_n = 463k > 72k$ Check service load deflection Max permiss. Δ $= \left(\frac{1}{800}\right)(12)(24) = 0.36 \text{ in.}$ $\Delta = \frac{(1000)(12)(2) + (4320)(20)}{EI}$ $= \frac{112,330 \text{ ft}^3}{EI}$ $= \frac{(112,330)(1728)(1000)}{(29 \times 10^3)(3990)}$ $= 1.678 \text{ in.} > 0.36 \text{ in.}$ Min. $I_x = \left(\frac{1.678}{0.36}\right)(3990) = 18,598 \text{ in}^4$ <div style="border: 1px solid black; padding: 2px; display: inline-block;">USE $W44 \times 230$</div> </p>	<p>Max $M_a = 720 \text{ ft-k}$ Max $V_a = 15 + 30 = 45k$ Using AISC Table 3-2 Try $W30 \times 99$ ($I_x = 3990 \text{ in}^4$) $\frac{M_n}{\Omega_b} = 778 \text{ ft-k} > 720 \text{ ft-k}$ $\frac{V_n}{\Omega_v} = 308k > 45k$ Check service load deflection Max permiss. Δ $= \left(\frac{1}{800}\right)(12)(24) = 0.36 \text{ in.}$ $\Delta = \frac{(1000)(12)(2) + (4320)(20)}{EI}$ $= \frac{112,330 \text{ ft}^3}{EI}$ $= \frac{(112,330)(1728)(1000)}{(29 \times 10^3)(3990)}$ $= 1.678 \text{ in.} > 0.36 \text{ in.}$ Min. $I_x = \left(\frac{1.678}{0.36}\right)(3990) = 18,598 \text{ in}^4$ <div style="border: 1px solid black; padding: 2px; display: inline-block;">USE $W44 \times 230$</div> </p>

EXCLUSIVE: Just in Edutruth only

PROB # 10-22

Assume beam $w_t = 180 \text{ lbs/ft}$

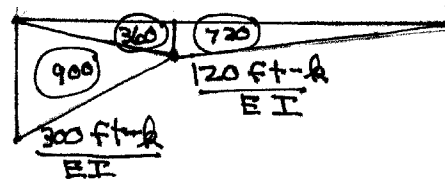


$$M_u = (32)(6) + (16)(18) + (1.416)(18)(9) = 709.4 \text{ ft-k}$$

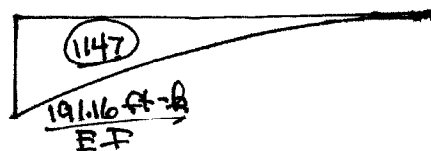
$$V_u = 32 + 16 + (18)(1.416) = 73.49 \text{ k}$$

Try W24x76 ($\phi_b M_{px} = 750 \text{ ft-k}$, $\phi_v V_{mx} = 316 \text{ k}$, $I = 2100 \text{ in}^4$)

Calculating deflections for service loads @ free end



$\frac{M}{EI}$ diag. for concn. loads



$\frac{M}{EI}$ diag. for uniform load

$$\Delta = \frac{(720)(8) + (360)(14) + (900)(6) + (1147)(\frac{3}{4})(18)}{EI} = \frac{40,684 \text{ ft}^3\text{-k}}{EI}$$

$$= \frac{(40,684)(1728)(1000)}{(29 \times 10^6)(2100)} = 1.1544 \text{ in.}$$

Max permissible $\Delta = (\frac{1}{1200})(12 \times 18) = 0.18 \text{ in.} < 1.1544 \text{ in.}$

Min I for both LRFD and ASD

$$= \frac{1.1544}{0.18} (2100) = 13,468 \text{ in}^4$$

USE W40x199 FOR BOTH LRFD AND ASD

✓ OCM

246

EXCLUSIVE: Just in Edutruth only

PROB# 10-23

Design of beams

Assume beam $w_t = 50 \text{ lbs/ft}$

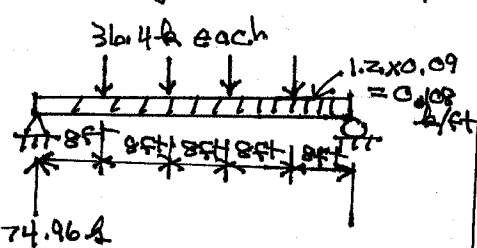
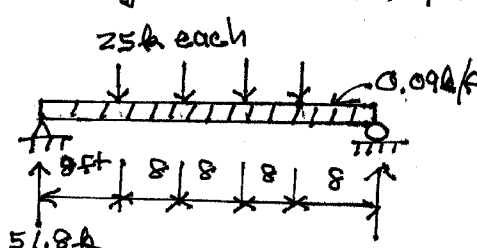
Slab $w_t = (8)(\frac{4}{12})(150) = 400$

$w_D = 450 \text{ lbs/ft}$

$w_L = (8)(100) = 800 \text{ lbs/ft}$

LRFD	ASD
$w_u = (1.2)(0.45) + (1.6)(0.8) = 1.82 \text{ k/ft}$ $M_u = \frac{(1.82)(40)^2}{8} = 364 \text{ ft-k}$ <div>USE W21x48</div>	$w_a = 0.45 + 0.8 = 1.25 \text{ k/ft}$ $M_a = \frac{(1.25)(40)^2}{8} = 250 \text{ ft-k}$ <div>USE W21x48</div>

Design of girders

LRFD	ASD
<p>End reaction of beam = $(20)(1.82) = 36.4 \text{ k}$</p> <p>Assume girder $w_t = 0.09 \text{ k/ft}$</p>  <p>$M_u = (74.96)(20) - (36.4)(4 + 12) - (0.198)(20)(10) = 895.2 \text{ ft-k}$</p> <div>USE W27x84</div>	<p>End reaction of beam = $(20)(1.25) = 25 \text{ k}$</p> <p>Assume girder $w_t = 0.09 \text{ k/ft}$</p>  <p>$M_a = (51.8)(20) - (25)(12) - (0.09)(20)(10) = 618 \text{ ft-k}$</p> <div>USE W30x90</div>

EXCLUSIVE: Just in Edutruth only

PROB# 10-24

(a) Design of Beams

Dead loads

Assume beam wt = 68 lbs/ft

$$\text{Slab wt} = \left(\frac{4}{12} \times 150\right)(8) = 400$$

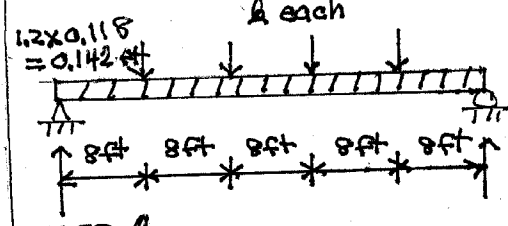
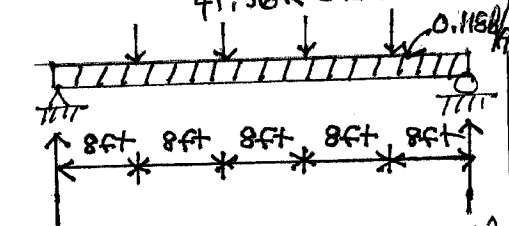
$$w_D = 468 \text{ lbs/ft}$$

Live loads

$$w_L = (200)(8) = 1600 \text{ lbs/ft}$$

LRFD	ASD
$w_u = (1.2)(0.468) + (1.6)(1.600) = 3.122 \text{ k/ft}$	$w_a = 0.468 + 1.600 = 2.068 \text{ k/ft}$
$M_u = \frac{(3.122)(40)^2}{8} = 624.4 \text{ ft-k}$	$M_a = \frac{(2.068)(40)^2}{8} = 413.6 \text{ ft-k}$
USE W24X68 (AISC Table 3-2)	USE W24X68 (AISC Table 3-2)

(b) Design of girders

LRFD	ASD
<p>Beam reactions to girders</p> $P_u = (20)(3.122) = 62.44 \text{ k}$ <p>Assume girder wt = 118 lbs/ft</p> <p>1.2 x 0.118 = 0.142 k/ft</p>  <p>127.72 k</p> $M_u = (127.72)(20) - (62.44)(4+12) - (0.142)(20)(10) = 1527 \text{ ft-k}$ <p>USE W33X118</p>	<p>Beam reactions to girders</p> $P_a = (20)(2.068) = 41.36 \text{ k}$ <p>Assume girder wt = 118 lbs/ft</p> <p>41.36 k each</p>  <p>85.08 k</p> $M_a = (85.08)(20) - (41.36)(4+12) - (20)(0.118)(10) = 1462 \text{ ft-k}$ <p>USE W33X118</p>

EXCLUSIVE: Just in Edutruth only

PROB # 10-25

Design of beams

Assume beam $w_t = 60 \text{ lbs/ft}$

$$\text{Slab } w_t = (8) \left(\frac{4}{12} \right) (150) = 400$$

$$w_D = 460 \text{ lbs/ft}$$

$$w_L = (8)(100) = 800 \text{ lbs/ft}$$

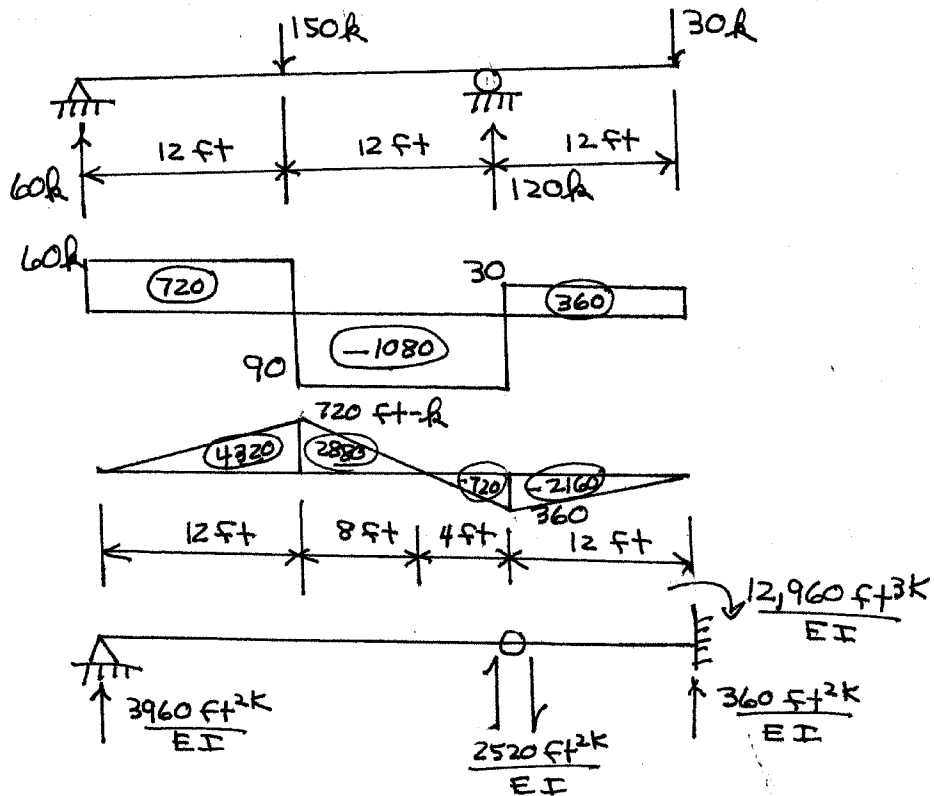
LRFD	ASD
$w_u = (1.2)(0.46) + (1.6)(0.8)$ $= 1.832 \text{ k/ft}$ $M_u = \frac{(1.832)(44)^2}{8} = 443.3 \text{ ft-k}$ <div>USE W18X60 ($d = 18.2 \text{ in.}$)</div>	$w_a = 0.46 + 0.8 = 1.26 \text{ k/ft}$ $M_a = \frac{(1.26)(44)^2}{8} = 304.9 \text{ ft-k}$ <div>USE W18X60 ($d = 18.2 \text{ in.}$)</div>

Vgcm

EXCLUSIVE: Just in Edutruth only

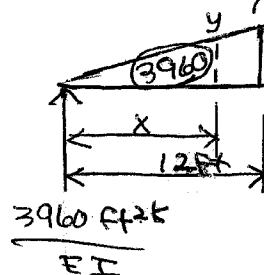
PROB# 10-26

Deflection for service loads (Using Conjugate beam)



Design for deflection

Maximum deflection occurs @ point of zero shear when conjugate beam loaded with $\frac{M}{EI}$ diag.



$$\frac{x}{12} = \frac{y}{720}$$

$$y = 60x$$

$$\left(\frac{1}{2}x\right)(60x) = 3960$$

$$x = 11.49 \text{ ft}$$

$$\text{Max } \Delta = \frac{(3960)(11.49 - \frac{11.49^2}{3})}{EI} = \frac{39333 \text{ ft}^3\text{k}}{EI}$$

250

EXCLUSIVE: Just in Edutruth only

$$\text{Max permissible } \Delta = \frac{(12)(24)}{1500} = 0.192 \text{ in.}$$

$$\frac{30,333 \text{ ft}^3/\text{s}}{EI} = 0.192$$

$$\frac{(30,333)(1728)(1000)}{(29 \times 10^6)(I)} = 0.192$$

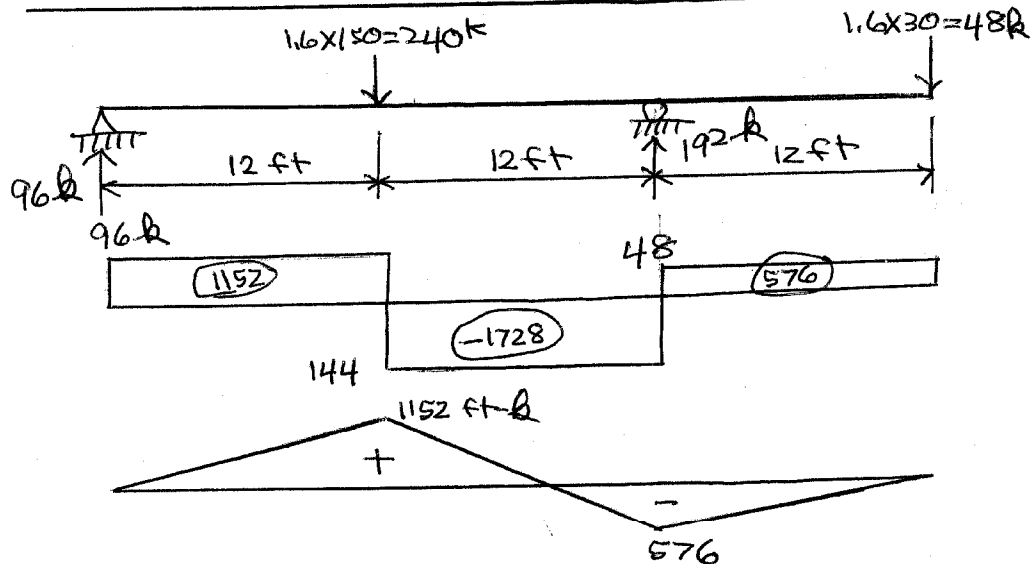
$$\text{Min. } I = 9414 \text{ in.}^4$$

Try W40x149 ($\phi_b M_{px} = 2240 \text{ ft-k}$, $\frac{M_{px}}{\Omega_b} = 1490 \text{ ft-k}$,

$$\phi_v V_{mx} = 650 \text{ k}, \frac{V_{mx}}{\Omega_v} = 432 \text{ k}, L_p = 8.09 \text{ ft},$$

$$L_n = 23.5 \text{ ft}, \text{BF for LRFD} = 58.0, \text{BF for ASD} = 38.6)$$

Factored load shear and moment diagrams



Checking section for moment and shear

LRFD	ASD
$\phi_b M_m = 1.0 [2240 - 58.0(12 - 8.09)]$ $= 2013 \text{ ft-k} > 1152 \text{ ft-k} \quad \text{OK}$	$\frac{M_m}{\Omega_b} = 1.0 [1490 - 38.6(12 - 8.09)]$ $= 1339 \text{ ft-k} > 720 \text{ ft-k}$
$\phi_v V_{mx} = 650 \text{ k}$ $> 144 \text{ k} \quad \text{OK}$	$\frac{V_{mx}}{\Omega_v} = 432 \text{ k} > 90 \text{ k} \quad \text{OK}$
USE W 40 x 149	USE W 40 x 149

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EXCLUSIVE: Just in Edutruth only

PROB #10-27

LRFD	ASD
<p style="text-align: center;">$1.6 \times 300 = 480k$ $1.6 \times 60 = 96k$</p> <p style="text-align: center;">From AISC Table 3-10 Try W40x199 Check shear AISC Table 3-2 $\phi_v V_n = 754k > 288k$ <u>OK</u></p> <div style="border: 1px solid black; padding: 5px; text-align: center; margin-top: 10px;">USE W40x199</div>	<p style="text-align: center;">$300k$ $60k$</p> <p style="text-align: center;">From AISC Table 3-10 Try W40x199 Check shear AISC Table 3-2 $\frac{V_n}{\Omega_v} = 503k > 180k$ <u>OK</u></p> <div style="border: 1px solid black; padding: 5px; text-align: center; margin-top: 10px;">USE W40x199</div>

✓ JCMC

EXCLUSIVE: Just in Edutruth only

PROB# 10-28

Using a W24x176 ($d = 25.2$ in., $b_f = 12.9$ in., $t_w = 0.750$ in.,
 $t_f = 1.34$ in., $k = 1.84$ in.)

LRFD	ASD
<p>Check shear (AISC Table 3-2)</p> $\phi V_{mx} = 482 \text{ k} > 320.53 \text{ k} \quad \text{OK}$	<p>Check shear (AISC Table 3-2)</p> $\frac{V_{mx}}{\Omega_v} = 322 \text{ k} > 200 \text{ k} \quad \text{OK}$
<p>Check web yielding @ left end</p> $R_m = (2.5k + N)F_{yw}t_w \quad (\text{AISC Eq J10-3})$ $= [(2.5)(1.84) + 8](50)(0.750) = 472.5 \text{ k}$ $\phi R_m = (0.75)(472.5) = 354.4 \text{ k}$ $> 320.53 \text{ k} \quad \text{OK}$	<p>Check web yielding @ left end</p> $R_m = 472.5 \text{ k}$ $\frac{R_m}{\Omega} = \frac{472.5}{2.00} = 236.25 > 200 \text{ k} \quad \text{OK}$
<p>Check web crippling @ left end</p> $\frac{N}{d} = \frac{8}{25.2} = 0.317 > 0.20$ $R_m = 0.40t_w^2 \left[1 + \left(\frac{4N}{d} - 0.2 \right) \left(\frac{t_w}{t_f} \right)^{1.5} \right] \frac{E F_y t_f}{0.75}$ $= (0.40)(0.750)^2 \left[1 + \left(\frac{4 \times 8}{25.2} - 0.2 \right) \left(\frac{0.750}{1.34} \right)^{1.5} \right] \frac{(29,000)(50)(1.34)}{0.75}$ $= 524.4 \text{ k}$ $\phi R_m = (0.75)(524.4) = 393.3 \text{ k}$ $> 320.53 \text{ k} \quad \text{OK}$	<p>Check web crippling @ left end</p> $R_m = 524.4 \text{ k}$ $\frac{R_m}{\Omega} = \frac{524.4}{2.00} = 262.2 \text{ k}$ $> 200 \text{ k} \quad \text{OK}$

EXCLUSIVE: Just in Edutruth only

PROB#10-28 CONTD.

LRFD	ASD
Check web yielding @ concn. load	Check web yielding @ concn. load
$R_m = (5k + N) F_{yw} t_w$ (AISC Eq. J10-2) $= (5 \times 1.84 + 12)(50)(0.750) = 795 k$ $\phi R_m = (1.00)(795) = 795 k > 480 k$ <u>OK</u>	$R_m = 795 k$ $\frac{R_m}{\Omega} = \frac{795}{1.50} = 530 k > 300 k$ <u>OK</u>
Check web crippling @ concn. load	Check web crippling @ concn. load
$R_m = 0.80 t_w^2 \left[1 + 3 \left(\frac{N}{d} \right) \left(\frac{t_w}{t_f} \right)^{1.5} \sqrt{\frac{E F_{yw} t_f}{t_w}} \right]$ $= (0.80)(0.750)^2 \left[1 + 3 \left(\frac{12}{25.2} \right) \left(\frac{0.750}{1.34} \right)^{1.5} \sqrt{\frac{(29 \times 10^3)(50)(1.34)}{0.750}} \right]$ $= 1157.6 k$ $\phi R_m = (0.75)(1157.6) = 868.2 k$ $> 480 k$ <u>OK</u>	$R_m = 1157.6 k$ $\frac{R_m}{\Omega} = \frac{1157.6}{2.00} = 578.8 k > 300 k$ <u>OK</u>

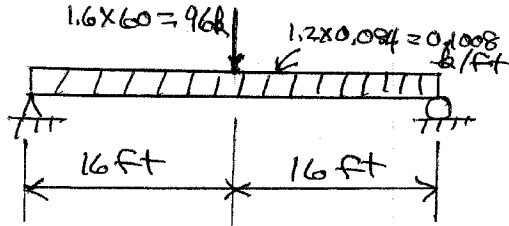
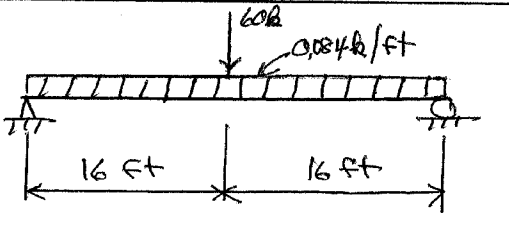
✓ JCMC

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EXCLUSIVE: Just in Edutruth only

PROB #10-29

Assume beam wt = 84 lbs/ft

LRFD	ASD
 <p>Design for moment</p> $M_u = \frac{(96)(32)}{4} + \frac{(0.1008)(32)^2}{8} = 780.9 \text{ k-ft}$ <p>Try W24X84 ($\phi_b M_{px} = 840 \text{ k-ft}$)</p> <p>$\phi_v V_{mx} = 340 \text{ k}$, $d = 24.1 \text{ in.}$, $t_w = 0.470 \text{ in.}$ $t_f = 0.770 \text{ in.}$, $b_f = 12.7 \text{ in.}$</p> <p>check max shear</p> <p>with load @ end</p> $V_u = 96 + (16)(0.1008) = 97.6 \text{ k}$ $< \phi_v V_{mx} = 340 \text{ k} \quad \text{OK}$ <p>Min bearing L of support</p> <p>for web yielding</p> $R_m = (2.5b + N) F_y w - t_w \quad (\text{AISC Eq. J10.3})$ $97.6 = (2.5 \times 12.7 + N)(50)(0.470)$ $N = 0.978 \text{ in.}$ <p>Min bearing L of support</p> <p>for web crippling</p> <p>Assume $\frac{N}{d} \leq 0.2$</p> $R_m = 0.40 t_w^2 \left[1 + 3 \left(\frac{N}{d} \right) \left(\frac{t_w}{t_f} \right)^{1.5} \right] \sqrt{\frac{E F_y w t_w}{t_f}}$ $97.6 = 0.40 (0.470)^2 \left[1 + 3 \left(\frac{N}{24.1} \right) \left(\frac{0.470}{0.770} \right)^{1.5} \right] \sqrt{\frac{(29 \times 10^3)(50)(0.470)}{0.470}}$ <p>N = negative number</p> <p>USE 3 in min</p>	 <p>Design for moment</p> $M_a = \frac{(60)(32)}{4} + \frac{(0.084)(32)^2}{8} = 499.5 \text{ k-ft}$ <p>Try W24X76 ($\frac{M_{px}}{\phi_b} = 499 \text{ k-ft}$)</p> <p>$\frac{V_{mx}}{\phi_v} = 210 \text{ k}$, $d = 23.9 \text{ in.}$, $t_w = 0.440 \text{ in.}$ $t_f = 0.680 \text{ in.}$, $b_f = 11.8 \text{ in.}$</p> <p>Check max shear</p> <p>with load @ end</p> $V_a = 60 + (16)(0.084) = 61.34 \text{ k} < 210 \text{ k}$ <p>min bearing L of support for</p> <p>web yielding</p> $R_m = (2.5b + N) F_y w - t_w$ $61.34 = (2.5 \times 11.8 + N)(50)(0.440)$ $N = < 0$ <p>Min bearing L of support</p> <p>for web crippling</p> <p>Assume $\frac{N}{d} \leq 0.2$</p> $R_m = 0.40 t_w^2 \left[1 + 3 \left(\frac{N}{d} \right) \left(\frac{t_w}{t_f} \right)^{1.5} \right] \sqrt{\frac{E F_y w t_w}{t_f}}$ $61.34 = 0.40 (0.440)^2 \left[1 + 3 \left(\frac{N}{23.9} \right) \left(\frac{0.440}{0.680} \right)^{1.5} \right] \sqrt{\frac{(29 \times 10^3)(50)(0.440)}{0.440}}$ <p>N = negative no</p> <p>USE 3 in. min</p>

EXCLUSIVE: Just in Edutruth only

PROB # 10-30

LRFD	ASD
$M_{ux} = (1.2)(150) + (1.6)(200) = 500 \text{ ft-k}$	$M_{ax} = 150 + 200 = 350 \text{ ft-k}$
$M_{uy} = (1.2)(40) + (1.6)(100) = 208 \text{ ft-k}$	$M_{ay} = 40 + 100 = 140 \text{ ft-k}$

After some trial and error

TRY W30X173

LRFD	ASD
<p>From AISC Tables 3-2 and 3-4</p> <p>$\phi_b M_{mx} = 2280 \text{ ft-k}$</p> <p>$\phi_b M_{my} = 461 \text{ ft-k}$</p> <p>$\frac{M_{ux}}{\phi_b M_{mx}} + \frac{M_{uy}}{\phi_b M_{my}} = \frac{500}{2280} + \frac{208}{461}$</p> <p>$= 0.670 < 1.00$</p> <div style="border: 1px solid black; padding: 5px; width: fit-content;"> <p>USE W30X173 (Next lighter section will not do)</p> </div>	<p>From AISC Tables 3-2 and 3-4</p> <p>$\frac{M_{mx}}{\Omega_b} = 1510 \text{ ft-k}$</p> <p>$\frac{M_{my}}{\Omega_b} = 307 \text{ ft-k}$</p> <p>$\frac{M_{ax}}{\frac{M_{mx}}{\Omega_b}} + \frac{M_{ay}}{\frac{M_{my}}{\Omega_b}} = \frac{350}{1510} + \frac{140}{307} = 0.698 < 1.0$</p> <div style="border: 1px solid black; padding: 5px; width: fit-content;"> <p>USE W30X173</p> </div>

✓ JCM

EXCLUSIVE: Just in Edutruth only

PROB #10-31

LRFD	ASD
$w_a = (1.2)(1.2) + (1.6)(3.4) = 6.88 \text{ k/ft}$	$w_a = 1.2 + 3.4 = 4.6 \text{ k/ft}$
$w_{ux} = \left(\frac{3}{\sqrt{10}}\right)(6.88) = 6.53 \text{ k/ft}$	$w_{ux} = \left(\frac{3}{\sqrt{10}}\right)(4.6) = 4.36 \text{ k/ft}$
$w_{uy} = \left(\frac{1}{\sqrt{10}}\right)(6.88) = 2.18 \text{ k/ft}$	$w_{uy} = \left(\frac{1}{\sqrt{10}}\right)(4.6) = 1.45 \text{ k/ft}$
$M_{ux} = \frac{(6.53)(20)^2}{8} = 326.5 \text{ ft-k}$	$M_{ux} = \frac{(4.36)(20)^2}{8} = 218 \text{ ft-k}$
$M_{uy} = \frac{(2.18)(20)^2}{8} = 109 \text{ ft-k}$	$M_{uy} = \frac{(1.45)(20)^2}{8} = 72.5 \text{ ft-k}$

After several attempts Try W33X118

LRFD	ASD
$\frac{M_{ux}}{\phi_b M_{px}} + \frac{M_{uy}}{\phi_b M_{py}}$ $= \frac{326.5}{1560} + \frac{109}{192} = 0.777 < 1.0$ <div style="border: 1px solid black; padding: 2px; display: inline-block;">USE W33X118</div>	$\frac{M_{ux}}{\frac{M_{px}}{2.6}} + \frac{M_{uy}}{\frac{M_{py}}{2.6}}$ $= \frac{218}{1040} + \frac{72.5}{128} = 0.776 < 1.0$ <div style="border: 1px solid black; padding: 2px; display: inline-block;">USE W33X118</div>

Note: Seems somewhat oversized but this is the smallest W33 available.

VJCM

EXCLUSIVE: Just in Edutruth only

PROB # 10-32

L RFD	ASD
$w_u = (1.2)(1.2) + (1.6)(4.8) = 9.12 \text{ k/ft}$	$w_d = 1.2 + 4.8 = 6.0 \text{ k/ft}$
$w_{ux} = \left(\frac{3}{\sqrt{10}}\right)(9.12) = 8.65 \text{ k/ft}$	$w_{dx} = \left(\frac{3}{\sqrt{10}}\right)(6.0) = 5.698 \text{ k/ft}$
$w_{uy} = \left(\frac{1}{\sqrt{10}}\right)(9.12) = 2.88 \text{ k/ft}$	$w_{dy} = \left(\frac{1}{\sqrt{10}}\right)(6.0) = 1.90 \text{ k/ft}$
$M_{ux} = \frac{(8.65)(20)^2}{8} = 432.5 \text{ ft-k}$	$M_{dx} = \frac{(5.69)(20)^2}{8} = 284.5 \text{ ft-k}$
$M_{uy} = \frac{(2.88)(20)^2}{8} = 144 \text{ ft-k}$	$M_{dy} = \frac{(1.90)(20)^2}{8} = 95 \text{ ft-k}$

After some study of AISC Tables 3-2 and 3-4

Try W33X130 ($\phi_b M_{px} = 1750 \text{ ft-k}$, $\phi_b M_{py} = 223 \text{ ft-k}$,

$$\frac{M_{px}}{\phi_b} = 1170 \text{ ft-k}, \frac{M_{py}}{\phi_b} = 148 \text{ ft-k})$$

$\frac{M_{ux}}{\phi_b M_{px}} + \frac{M_{uy}}{\phi_b M_{py}}$ $= \frac{432.5}{1750} + \frac{144}{223} = 0.893 < 1.0$ <div style="border: 1px solid black; padding: 2px; display: inline-block;">USE W33X130</div>	$\frac{M_{dx}}{\phi_b} + \frac{M_{dy}}{\phi_b}$ $= \frac{284.5}{1170} + \frac{95}{148} = 0.885 < 1.0$ <div style="border: 1px solid black; padding: 2px; display: inline-block;">USE W33X130</div>
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✓ 9 CM²

EXCLUSIVE: Just in Edutruth only

PROB# 10-33

Using a W21x68 ($d = 21.1 \text{ in.}$, $t_w = 0.430 \text{ in.}$, $b_f = 8.27 \text{ in.}$,
 $t_f = 0.685 \text{ in.}$, $h = 1.19 \text{ in.}$)

Compute plate area A_1

LRFD $\phi_c = 0.60$	ASD $\Omega_c = 2.50$
$R_u = (1.2)(25) + (1.6)(40) = 94 \text{ k}$ $A_1 = \frac{R_u}{\phi_c 0.85 F_c} = \frac{94}{(0.6)(0.85)(4)} = 46.07 \text{ in.}^2$ <u>Try PL 8x6 (48 in.²) with</u> <u>6 in. - side = N parallel to beam.</u>	$R_a = 25 + 40 = 65 \text{ k}$ $A_1 = \frac{\Omega_c R_a}{0.85 F_c} = \frac{(2.50)(65)}{(0.85)(4)} = 47.79 \text{ in.}^2$ <u>Try PL 8x6 (48 in.²) with</u> <u>6 in. - side = N parallel to beam</u>

Check web local yielding

$$R_m = (2.5h + N) F_y t_w \quad (\text{AISC Eq. J10-3})$$

$$= (2.5 \times 1.19 + 6) (36) (0.430) = 138.93 \text{ k}$$

LRFD $\phi = 1.0$	ASD $\Omega = 1.50$
$R_u = \phi R_m = (1.00)(138.93)$ $= 138.93 \text{ k} > 94 \text{ k} \quad \underline{\text{OK}}$	$R_a = \frac{R_m}{\Omega} = \frac{138.93}{1.50}$ $= 92.62 \text{ k} > 65 \text{ k} \quad \underline{\text{OK}}$

EXCLUSIVE: Just in Edutruth only

PROB# 10-33 CONTD.

Check web crippling

$$\frac{N}{d} = \frac{6}{21.1} = 0.284 > 0.2 \therefore \text{Must use AISI Eq I 10-56}$$

$$R_m = 0.40 t_w^2 \left[1 + \left(\frac{4N}{d} - 0.2 \right) \left(\frac{t_w}{t_f} \right)^{1.5} \right] \sqrt{\frac{E F_{yw} t_f}{t_w}}$$

$$= (0.40)(0.43)^2 \left[1 + \left(\frac{4 \times 6}{21.1} - 0.2 \right) \left(\frac{0.43}{0.685} \right)^{1.5} \right] \sqrt{\frac{(29 \times 10^3)(36)(0.685)}{0.430}}$$

$$= 139.85 \text{ k}$$

LRFD $\phi = 0.75$	ASD $\Omega = 2.00$
$R_u = \phi R_m = (0.75)(139.85) = 104.89 \text{ k}$ $> 94.3 \text{ k}$ <u>OK</u>	$R_a = \frac{R_m}{\Omega} = \frac{139.85}{2.00} = 69.92 \text{ k}$ $> 65 \text{ k}$ <u>OK</u>

Determine plate thickness

$$m = \frac{g}{2} - 1.19 = 2.81 \text{ in.}$$

LRFD $\phi_b = 0.90$	ASD $\Omega_b = 1.67$
$t = \sqrt{\frac{2 R_u m^2}{\phi_b A_s F_y}} = \sqrt{\frac{(2)(94)(2.81)^2}{(0.9)(8 \times 6)(36)}}$ $= 0.977 \text{ in.}$	$t = \sqrt{\frac{2 R_a m^2 \Omega_b}{A_s F_y}} = \sqrt{\frac{(2)(65)(2.81)^2(1.67)}{(8 \times 6)(36)}}$ $= 0.996 \text{ in.}$
USE PL 1X8X6 $F_y = 36 \text{ ksi}$	USE PL 1X8X6 $F_y = 36 \text{ ksi}$

$r_g < m_c$

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EXCLUSIVE: Just in Edutruth only

PROB# 10-34

Using a W30x116 ($d = 30.0$ in., $t_w = 0.565$ in., $b_f = 10.5$ in.,
 $t_f = 0.850$ in., $k = 1.50$ in.)

LRFD $\phi_c = 0.6$	ASD $\Omega_c = 2.50$
$R_u = (1.2)(40) + (1.6)(80) = 176$ k $A_1 = \frac{R_u}{\phi_c 0.85 F_c} = \frac{176}{(0.6)(0.85)(3)} = 115.03$ in. ² Try PL 8x15 (120 in. ²)	$R_a = 40 + 80 = 120$ k $A_1 = \frac{\Omega_c R_a}{0.85 F_c} = \frac{(2.50)(120)}{(0.85)(3)} = 117.65$ in. ² Try PL 8x15 (120 in. ²)

Check web local yielding

$$R_m = (2.5A + N) F_y t_w \quad (\text{AISC Eq. J10-3})$$

$$= (2.5 \times 1.50 + 8)(50)(0.565) = 331.9 \text{ k}$$

LRFD $\phi = 1.0$	ASD $\Omega = 1.50$
$R_u = \phi R_m = (1.00)(331.9) = 331.9$ k > 176 k <u>OK</u>	$R_a = \frac{R_m}{\Omega} = \frac{331.9}{1.50} = 221.3$ k > 120 k <u>OK</u>

Check web crippling

$$\frac{N}{d} = \frac{8}{30.0} = 0.267 > 0.2 \therefore \text{Must use AISC Eq. J10-5 b}$$

$$R_m = 0.40 t_w^2 \left[1 + \left(\frac{4N}{d} - 0.2 \right) \left(\frac{t_w}{t_f} \right)^{1.5} \right] \sqrt{\frac{E F_y t_f}{t_w}}$$

$$= (0.40)(0.565)^2 \left[1 + \left(\frac{4 \times 8}{30.0} - 0.2 \right) \left(\frac{0.565}{0.850} \right)^{1.5} \right] \sqrt{\frac{(29 \times 10^3)(50)(0.850)}{0.565}}$$

$$= 277 \text{ k}$$

LRFD $\phi = 0.75$	ASD $\Omega = 2.00$
$\phi R_m = (0.75)(277) = 207.7$ k > 176 k <u>OK</u>	$\frac{R_m}{\Omega} = \frac{277}{2.00} = 138.5$ k > 120 k <u>OK</u>

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EXCLUSIVE: Just in Edutruth only

PROB# 10-34 CONTD.

Determine plate thickness

$$m = \frac{15}{2} = 1.50 = 6.00 \text{ in.}$$

LRFD $\phi = 0.90$	ASD $\Omega = 1.67$
$t = \sqrt{\frac{2R_u m^2}{\phi A_g F_y}} = \sqrt{\frac{(2)(176)(6)^2}{(0.9)(120)(50)}}$ $= 1.53 \text{ in.}$ <div style="border: 1px solid black; padding: 2px; display: inline-block;">USE PL $1\frac{3}{4} \times 8 \times 15$</div>	$t = \sqrt{\frac{2R_u m^2 \Omega}{A_g F_y}} = \sqrt{\frac{(2)(120)(6)^2(1.67)}{(120)(50)}}$ $t = 1.55 \text{ in.}$ <div style="border: 1px solid black; padding: 2px; display: inline-block;">USE PL $1\frac{3}{4} \times 8 \times 15$</div>

✓ JCMC

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EXCLUSIVE: Just in Edutruth only

CHAPTER 11

PROB #11-1

Using a W14X30 ($A_g = 8.85 \text{ in}^2$, $L_p = 5.26 \text{ ft} > 4 \text{ ft}$)

LRFD	ASD
$P_u = P_u = (1.2)(80) + (1.6)(100) = 256 \text{ k}$ $M_{ux} = M_{ux} = (1.2)(10) + (1.6)(12) = 31.2 \text{ ft-k}$ $P_c = \phi_c F_y A_g = (0.9)(50)(8.85) = 398.2 \text{ k}$ $M_{cx} = \phi_b M_{px} = 177 \text{ ft-k}$ from AISC Table 3-2 $\frac{P_u}{P_c} = \frac{256}{398.2} = 0.643 > 0.2$ \therefore Must use AISC Eq. H1-1a $\frac{P_u}{P_c} + \frac{8}{9} \left(\frac{M_{ux}}{M_{cx}} + \frac{M_{uy}}{M_{cy}} \right)$ $= 0.643 + \left(\frac{8}{9} \right) \left(\frac{31.2}{177} \right)$ $= 0.800 < 1.00 \text{ OK}$	$P_a = 80 + 100 = 180 \text{ k} = P_u$ $M_{ax} = M_{ax} = 10 + 12 = 22 \text{ ft-k}$ $P_c = \frac{P_n}{\Omega_c} = \frac{F_y A_g}{\Omega_c}$ $= \frac{(50)(8.85)}{1.67} = 265 \text{ k}$ $M_{cx} = \frac{M_{px}}{\Omega_b} = 118 \text{ ft-k}$ from AISC Table 3-2 $\frac{P_a}{P_c} = \frac{180}{265} = 0.679 > 0.2$ \therefore Must use AISC Eq. H1-1a $\frac{P_a}{P_c} + \frac{8}{9} \left(\frac{M_{ax}}{M_{cx}} + \frac{M_{ay}}{M_{cy}} \right)$ $= 0.679 + \left(\frac{8}{9} \right) \left(\frac{22}{118} \right)$ $= 0.845 < 1.00 \text{ OK}$

$\checkmark \phi_c M_c$

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EXCLUSIVE: Just in Edutruth only

PROB #11-2

Using a W12x58 ($A = 17.0 \text{ in}^2$, $L_p = 8.87 \text{ ft}$, $\phi_b M_{px} = 324 \text{ ft-k}$)

$$\frac{M_{px}}{\Omega_b} = 216 \text{ ft-k}$$

LRFD	ASD
$P_u = P_u = (1.2)(40) + (1.6)(50) = 128 \text{ k}$ $M_{ux} = M_{ux} = (1.2)(50) + (1.6)(60) = 156 \text{ ft-k}$ $P_c = \phi_c F_y A_g = (0.9)(50)(17.0) = 765 \text{ k}$ Noting $L_b = 8.0 \text{ ft} < L_p = 8.87 \text{ ft}$ $M_{cx} = \phi_b M_{px} = 324 \text{ ft-k}$ $\frac{P_u}{P_c} = \frac{128}{765} = 0.167 < 0.2$ \therefore Must use AISC Eq. H1-16 $\frac{P_u}{2P_c} + \frac{M_{ux}}{M_{cx}} + \frac{M_{uy}}{M_{cy}} = \frac{128}{(2)(765)} + \frac{156}{324} = 0.565 < 1.00 \quad \underline{\text{OK}}$	$P_u = P_u = 40 + 50 = 90 \text{ k}$ $M_{ux} = M_{ux} = 50 + 60 = 110 \text{ ft-k}$ $P_c = \frac{P_n}{\Omega_c} = \frac{F_y A_g}{\Omega_c} = \frac{(50)(17.0)}{1.67} = 509 \text{ k}$ $M_{cx} = \frac{M_{px}}{\Omega_b} = 216 \text{ ft-k}$ $\frac{P_u}{P_c} = \frac{90}{509} = 0.177 < 0.2$ \therefore Must use AISC Eq. H1-16 $\frac{P_u}{2P_c} + \frac{M_{ux}}{M_{cx}} + \frac{M_{uy}}{M_{cy}} = \frac{90}{(2)(509)} + \frac{110}{216} + 0 = 0.598 < 1.00 \quad \underline{\text{OK}}$

$\checkmark \phi_c M_c$

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EXCLUSIVE: Just in Edutruth only

PROB # 11-3

using a W14 x 30 ($A = 8.85 \text{ in.}^2$, $\phi_b M_{px} = 177 \text{ ft-k}$,

$$\frac{M_{px}}{\Omega_b} = 118 \text{ ft-k}, L_p = 5.26 \text{ ft})$$

LRFD	ASD
$P_u = P_u = (1.2)(80) + (1.6)(100) = 256$ $M_{ux} = M_{ux} = (1.2)(10) + (1.6)(12) = 31.2$ $M_{uy} = M_{uy} = (1.2)(10) + (1.6)(5) = 20$ $P_c = \phi_c F_y A_g = (0.9)(50)(8.85)$ $= 398.2 \text{ ft-k}$ $M_{cx} = \phi_b M_{px} = 172 \text{ ft-k}$ $M_{cy} = \phi_b M_{py} = 33.7 \text{ ft-k}$ $\frac{P_u}{P_c} = \frac{256}{398.2} = 0.643 > 0.2$ \therefore Must use AISC Eq H1-1a	$P_u = P_u = 80 + 100 = 180 \text{ k}$ $M_{ux} = M_{ux} = 10 + 12 = 22 \text{ ft-k}$ $M_{uy} = M_{uy} = 10 + 5 = 15 \text{ ft-k}$ $P_c = \frac{P_n}{\Omega_c} = \frac{F_y A_g}{\Omega_c} = \frac{(50)(8.85)}{1.67}$ $= 265 \text{ k}$ $M_{cx} = \frac{M_{mx}}{\Omega_b} = 118 \text{ ft-k}$ $M_{cy} = \frac{M_{my}}{\Omega_b} = 22.4 \text{ ft-k}$ $\frac{P_u}{P_c} = \frac{180}{265} = 0.679 > 0.2$ \therefore Must use AISC Eq H1-1a
$\frac{P_u}{P_c} + \frac{8}{9} \left(\frac{M_{ux}}{M_{cx}} + \frac{M_{uy}}{M_{cy}} \right) \leq 1.0$ $\frac{256}{398.2} + \frac{8}{9} \left(\frac{31.2}{172} + \frac{20}{33.7} \right)$ $= 1.332 > 1.00 \text{ N.G.}$	$\frac{P_u}{P_c} + \frac{8}{9} \left(\frac{M_{ux}}{M_{cx}} + \frac{M_{uy}}{M_{cy}} \right) \leq 1.0$ $\frac{180}{265} + \frac{8}{9} \left(\frac{22}{118} + \frac{15}{22.4} \right)$ $= 1.44 > 1.00 \text{ N.G.}$

✓ JCM

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EXCLUSIVE: Just in Edutruth only

PROB # 11-4

LRFD	ASD
$P_u = P_u = (1.2)(50) + (1.6)(30) = 188 \text{ k}$	$P_2 = P_a = 50 + 30 = 130 \text{ k}$
$M_{ux} = M_{ux} = (1.2)(40) + (1.6)(60) = 144 \text{ ft-k}$	$M_{ax} = M_{ax} = 40 + 60 = 100 \text{ ft-k}$

After some scratchwork Try a W12x40 ($A = 11.7 \text{ in}^2$)

LRFD	ASD
$P_c = \phi_t F_y A_g = (0.9)(50)(11.7) = 526.5 \text{ k}$	$P_c = \frac{P_n}{\Omega_t} = \frac{F_y A_g}{\Omega_t} = \frac{(50)(11.7)}{1.67} = 350.3 \text{ k}$
$M_{cx} = \phi_b M_{px} = 214 \text{ ft-k}$ from AISC Table 3-2	$M_{cx} = \frac{M_{px}}{\Omega_b} = 142 \text{ ft-k}$ from AISC Table 3-2
$\frac{P_u}{P_c} = \frac{188}{526.5} = 0.357 > 0.2$	$\frac{P_2}{P_c} = \frac{130}{350.3} = 0.371 > 0.2$
\therefore Must use AISC Eq. H1-1a	\therefore Must use AISC Eq. H1-1a
$\frac{P_u}{P_c} + \frac{8}{9} \left(\frac{M_{ux}}{M_{cx}} + \frac{M_{uy}}{M_{cy}} \right) = \frac{188}{526.5} + \frac{8}{9} \left(\frac{144}{214} + 0 \right) = 0.955 < 1.00 \text{ OK}$	$\frac{P_2}{P_c} + \frac{8}{9} \left(\frac{M_{ax}}{M_{cx}} + \frac{M_{ay}}{M_{cy}} \right) = \frac{130}{350.3} + \frac{8}{9} \left(\frac{100}{142} + 0 \right) = 0.997 < 1.00 \text{ OK}$
<u>USE W12x40</u>	<u>USE W12x40</u>

$\checkmark \phi_c m_c$

EXCLUSIVE: Just in Edutruth only

PROB # 11-5

LRFD	ASD
$P_u = P_n = 298 \text{ k}$	$P_n = P_a = 200 \text{ k}$
$M_{ux} = M_{ux} = 30 \text{ ft-k}$	$M_{ux} = M_{ax} = 24 \text{ ft-k}$

After some scratchwork Try a W14X30 ($A = 8.85 \text{ in}^2$)

LRFD	ASD
$P_c = \phi_c F_y A_g = (0.9)(50)(8.85) = 398.2 \text{ k}$ Noting $L_b > L_p < L_r$ $M_{cx} = \phi_b M_{px} = C_b [\phi_b M_{px} - BF(L_p - L_r)]$ $= 1.0 [177 - 6.99(10 - 5.26)]$ $= 143.9 \text{ ft-k}$ $\frac{P_u}{P_c} = \frac{298}{398.2} = 0.748 > 0.2$ \therefore Must use AISC Eq. H1-1a $\frac{P_u}{P_c} + \frac{8}{9} \left(\frac{M_{ux}}{M_{cx}} + \frac{M_{uy}}{M_{cy}} \right)$ $= \frac{298}{398.2} + \frac{8}{9} \left(\frac{30}{143.9} + 0 \right)$ $= 0.933 < 1.00 \quad \underline{\text{OK}}$ <u>USE W14 X30</u>	$P_c = \frac{P_n}{\Omega_c} = \frac{F_y A_g}{\Omega_c} = \frac{(50)(8.85)}{1.67} = 265 \text{ k}$ $M_{cx} = \frac{M_{px}}{\Omega_b} = C_b \left[\frac{M_{px}}{\Omega_b} - BF(L_p - L_r) \right]$ $= 1.0 [118 - 4.65(10 - 5.26)]$ $= 95.96 \text{ ft-k}$ $\frac{P_a}{P_c} = \frac{200}{265} = 0.755 > 0.2$ \therefore Must use AISC Eq. H1-1a $\frac{P_a}{P_c} + \frac{8}{9} \left(\frac{M_{ux}}{M_{cx}} + \frac{M_{uy}}{M_{cy}} \right)$ $= \frac{200}{265} + \frac{8}{9} \left(\frac{24}{95.96} + 0 \right)$ $= 0.977 < 1.00 \quad \underline{\text{OK}}$ <u>USE W14 X30</u>

✓ GCM

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EXCLUSIVE: Just in Edutruth only

PROB# 11-6

LRFD	ASD
$P_u = P_u = (1.2)(200) = 240 \text{ k}$	$P_2 = P_u = 200 \text{ k}$
$M_{ux} = M_{ux} = (1.2)(\frac{4}{12} \times 200) = 80 \text{ ft-k}$	$M_{ux} = M_{ux} = (\frac{4}{12})(200) = 66.7 \text{ ft-k}$

After some preliminary scratchwork Try a W12x35
 $(A = 10.3 \text{ in}^2, L_p = 5.44 \text{ ft}, L_r = 16.7 \text{ ft}, \phi_b M_{px} = 192 \text{ ft-k}, \frac{M_{px}}{\Omega_b} = 128 \text{ ft-k},$
 BF for LRFD = 6.43 k, BF for ASD = 4.28 k)

LRFD	ASD
$P_c = \phi_c F_y A_g = (0.9)(50)(10.3) = 463.5 \text{ k}$ Noting $L_b > L_p < L_r$ $M_{cx} = \phi_b M_{px} = C_b [\phi_b M_{px} - BF(L_b - L_p)]$ $= 1.0 [192 - 6.43(8 - 5.44)]$ $= 175.5 \text{ ft-k}$ $\frac{P_u}{P_c} = \frac{240}{463.5} = 0.518 > 0.2$ \therefore Must use AISC Eq. H1-1a $\frac{P_u}{P_c} + \frac{8}{9} \left(\frac{M_{ux}}{M_{cx}} + \frac{M_{uy}}{M_{cy}} \right)$ $= \frac{240}{463.5} + \frac{8}{9} \left(\frac{80}{175.5} + 0 \right)$ $= 0.923 < 1.00 \quad \underline{\text{OK}}$ <div style="border: 1px solid black; padding: 2px; display: inline-block;">USE W12x35</div>	$P_c = \frac{P_n}{\Omega_c} = \frac{F_y A_g}{\Omega_c} = \frac{(50)(10.3)}{1.67} = 308.4 \text{ k}$ Noting $L_b > L_p < L_r$ $M_{cx} = \phi_b M_{px} = C_b \left[\frac{M_{px}}{\Omega_b} - BF(L_b - L_p) \right]$ $= 1.0 [128 - 4.28(8 - 5.44)]$ $= 117.0 \text{ ft-k}$ $\frac{P_u}{P_c} = \frac{200}{308.4} = 0.649 > 0.2$ \therefore Must use AISC Eq. H1-1a $\frac{P_u}{P_c} + \frac{8}{9} \left(\frac{M_{ux}}{M_{cx}} + \frac{M_{uy}}{M_{cy}} \right)$ $= \frac{200}{308.4} + \frac{8}{9} \left(\frac{66.7}{117} + 0 \right)$ $= 1.16 > 1.0 \quad \underline{\text{N.G.}}$ <div style="border: 1px solid black; padding: 2px; display: inline-block;">USE W12x40</div>

✓ JCM

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EXCLUSIVE: Just in Edutruth only

PROB #11-7

LRFD	ASD
$P_u = P_n = (1.2)(200) = 240 \text{ k}$ $M_{ux} = M_{nx} = (1.2)(\frac{4}{12} \times 200) = 80 \text{ ft-k}$	$P_n = P_a = 200 \text{ k}$ $M_{ux} = M_{nx} = (\frac{4}{12})(200) = 66.7 \text{ ft-k}$

After some preliminary scratchwork Try a W14x34
 $(A = 10.0 \text{ in}^2, L_p = 5.40 \text{ ft}, L_r = 15.6 \text{ ft}, \phi_b M_{nx} = 205 \text{ ft-k},$
 $\frac{M_{px}}{\Omega_b} = 136 \text{ ft-k}, \text{BF for LRFD} = 7.59, \text{BF for ASD} = 5.05)$

LRFD	ASD
$P_c = \phi_c F_y A_g = (0.9)(50)(10.0) = 450 \text{ k}$ Noting $L_b > L_p < L_r$ $M_{cx} = \phi_b M_{px} = C_b [\phi_b M_{px} - \text{BF}(L_b - L_p)]$ $= 1.0 [205 - 7.59(8 - 5.40)]$ $= 185.3 \text{ ft-k}$ $\frac{P_u}{P_c} = \frac{240}{450} = 0.533 > 0.2$ \therefore Must use AISC Eq H1-1a $\frac{P_u}{P_c} + \frac{8}{9} \left(\frac{M_{ux}}{M_{cx}} + \frac{M_{uy}}{M_{cy}} \right)$ $= \frac{240}{450} + \frac{8}{9} \left(\frac{80}{185.3} + 0 \right)$ $= 0.917 < 1.00 \quad \text{OK}$ <div style="border: 1px solid black; padding: 2px; display: inline-block;">USE W14x34</div>	$P_c = \frac{P_n}{\Omega_c} = \frac{F_y A_g}{\Omega_c} = \frac{(50)(10.0)}{1.67} = 299.4 \text{ k}$ Noting $L_b > L_p < L_r$ $M_{cx} = \frac{M_{px}}{\Omega_b} = C_b \left[\frac{M_{px}}{\Omega_b} - \text{BF}(L_b - L_p) \right]$ $= 1.0 [136 - 5.05(8 - 5.40)]$ $= 122.9 \text{ ft-k}$ $\frac{P_n}{P_c} = \frac{200}{299.4} = 0.668 > 0.2$ \therefore Must AISC Eq. H1-1a $\frac{P_n}{P_c} + \frac{8}{9} \left(\frac{M_{ux}}{M_{cx}} + \frac{M_{uy}}{M_{cy}} \right)$ $= \frac{200}{299.4} + \frac{8}{9} \left(\frac{66.7}{122.9} + 0 \right)$ $= 1.15 > 1.00 \quad \text{N.G.}$ <div style="border: 1px solid black; padding: 2px; display: inline-block;">USE W14x43</div>

✓ $\phi_c M_c$

EXCLUSIVE: Just in Edutruth only

PROB #11-8

LRFD	ASD
$M_{rx} = M_{ux} = 100 \text{ ft-k}$	$M_{rx} = M_{ux} = 60 \text{ ft-k}$

Using a W12x72 ($A = 21.1 \text{ in}^2$, $\phi_b M_{px} = 405 \text{ ft-k}$, $\frac{M_{px}}{\Omega_b} = 269 \text{ ft-k}$)

LRFD	ASD
$P_c = \phi_b F_y A_g = (0.9)(50)(21.1) = 949.5 \text{ k}$ Assume $\frac{P_r}{P_c} > 0.2$, therefore requiring the use of AISC Eq. H1-1a $\frac{P_r}{P_c} + \frac{8}{9} \left(\frac{M_{rx}}{M_{cx}} + \frac{M_{ry}}{M_{cy}} \right) = 1.00$ $\frac{P_r}{949.5} + \frac{8}{9} \left(\frac{100}{405} + 0 \right) = 1.00$ $P_r = 741.1 \text{ k}$	$P_c = \frac{P_n}{\Omega_t} = \frac{F_y A_g}{\Omega_t} = \frac{(50)(21.1)}{1.67} = 631.7 \text{ k}$ Assume $\frac{P_r}{P_c} > 0.2$ thus requiring the use of AISC Eq. H1-1a $\frac{P_r}{P_c} + \frac{8}{9} \left(\frac{M_{rx}}{M_{cx}} + \frac{M_{ry}}{M_{cy}} \right) = 1.00$ $\frac{P_r}{631.7} + \frac{8}{9} \left(\frac{60}{269} + 0 \right) = 1.00$ $P_r = 506.5 \text{ k}$

✓ gcm

EXCLUSIVE: Just in Edutruth only

PROB #11-9

LRFD	ASD
$M_{ux} = M_{ux} = 100 \text{ ft-k}$	$M_{ux} = M_{ux} = 60 \text{ ft-k}$

Using a W12x72 ($A = 21.1 \text{ in}^2$, $Z_x = 108 \text{ in}^3$)

LRFD	ASD
$P_c = \phi_t F_y A_g = (0.9)(36)(21.1) = 683.6 \text{ k}$ $M_{cx} = \phi_b M_{px} = \phi_b F_y Z$ $= \frac{(0.9)(36)(108)}{12} = 291.6 \text{ ft-k}$ Assume $\frac{P_u}{P_c} > 0.2$ thus requiring the use of AISC Eq. H1-1a $\frac{P_u}{P_c} + \frac{8}{9} \left(\frac{M_{ux}}{M_{cx}} + \frac{M_{uy}}{M_{cy}} \right) \leq 1.0$ $\frac{P_u}{683.6} + \frac{8}{9} \left(\frac{100}{291.6} + 0 \right) = 1.00$ $P_u = 475.2 \text{ k}$	$P_c = \frac{P_n}{\Omega_t} = \frac{F_y A_g}{\Omega_t} = \frac{(36)(21.1)}{1.67} = 454.9 \text{ k}$ $M_{cx} = \frac{F_y Z_x}{\Omega_b} = \frac{(36)(108)}{(1.67)(12)} = 194 \text{ ft-k}$ Assume $\frac{P_u}{P_c} > 0.2$ thus requiring the use of AISC Eq. H1-1a $\frac{P_u}{P_c} + \frac{8}{9} \left(\frac{M_{ux}}{M_{cx}} + \frac{M_{uy}}{M_{cy}} \right) \leq 1.00$ $\frac{P_u}{454.9} + \left(\frac{8}{9} \right) \left(\frac{60}{194} \right) = 1.00$ $P_u = 329.8 \text{ k}$

✓ $\phi_c M_c$

EXCLUSIVE: Just in Edutruth only

PROB # 11-10

Using a W10x54 ($A = 15.8 \text{ in}^2$, $I_x = 303 \text{ in}^4$, $\phi_b M_{px} = 250 \text{ ft-k}$,
 $\frac{M_{px}}{\Omega_b} = 166 \text{ ft-k}$, $L_p = 9.04 \text{ ft}$, $L_r = 33.7 \text{ ft}$, For LRFD
 $\text{BF} = 3.74$, For ASD $\text{BF} = 2.49$)

LRFD	ASD
$P_u = P_n = 300 \text{ k}$ $M_u = M_n = (300)\left(\frac{2}{12}\right) = 50 \text{ ft-k}$ $K_x L_x = K_y L_y = (1.0)(15) = 15 \text{ ft}$ $P_c = \phi_c P_n = 496 \text{ k}$ $\frac{P_u}{P_c} = \frac{300}{496} = 0.605 > 0.2$ \therefore Must use AISC Eq. H1-1a	$P_n = P_a = 180 \text{ k}$ $M_n = M_a = (90)\left(\frac{2}{12}\right) = 30 \text{ ft-k}$ $K_x L_x = K_y L_y = (1.0)(15) = 15 \text{ ft}$ $P_c = \frac{P_n}{\Omega_c} = 330 \text{ k}$ $\frac{P_a}{P_c} = \frac{180}{330} = 0.545 > 0.2$ \therefore Must use AISC Eq. H1-1a
$C_m = 0.6 - 0.4 \frac{M_1}{M_2}$ $= 0.6 - 0.4 \left(-\frac{50}{50}\right) = 1.00$ $P_{el} = \frac{\pi^2 EI_x}{(K_x L_x)^2} = \frac{\pi^2 (29 \times 10^3)(303)}{(12 \times 15)^2} = 2667 \text{ k}$ $B_1 = \frac{C_m}{1 - \alpha \frac{P_u}{P_{el}}} = \frac{1.0}{1 - (1.0) \frac{300}{2667}} = 1.13$ $M_{2x} = B_1 M_2 = (1.13)(50) = 56.5 \text{ ft-k}$ Since $L_b = 15 \text{ ft} > L_p < L_r$ $M_{ox} = \phi_b M_{mx} = 1.0 [250 - 3.74(15 - 9.04)]$ $= 227.7 \text{ ft-k}$ $\frac{P_u}{P_c} + \frac{8}{9} \left(\frac{M_{ux}}{M_{ox}} + \frac{M_{uy}}{M_{oy}} \right)$ $= \frac{300}{496} + \frac{8}{9} \left(\frac{56.5}{227.7} \right) = 0.826 < 1.00$ <div style="border: 1px solid black; padding: 2px; display: inline-block;">Section is satisfactory</div>	$C_m = 0.6 - 0.4 \frac{M_1}{M_2}$ $= 0.6 - 0.4 \left(-\frac{30}{30}\right) = 1.00$ $P_{el} = \frac{\pi^2 EI_x}{(K_x L_x)^2} = \frac{\pi^2 (29 \times 10^3)(303)}{(12 \times 15)^2} = 2667 \text{ k}$ $B_1 = \frac{C_m}{1 - \alpha \frac{P_a}{P_{el}}} = \frac{1.0}{1 - (1.0) \frac{180}{2667}} = 1.12$ $M_{2x} = (1.12)(30) = 33.6 \text{ ft-k}$ Since $L_b = 15 \text{ ft} > L_p < L_r$ $M_{ox} = \phi_b M_{mx} = 1.0 [166 - 2.49(15 - 9.04)]$ $= 151.2 \text{ ft-k}$ $\frac{P_a}{P_c} + \frac{8}{9} \left(\frac{M_{ux}}{M_{ox}} + \frac{M_{uy}}{M_{oy}} \right)$ $= \frac{180}{330} + \frac{8}{9} \left(\frac{33.6}{151.2} \right) = 0.743 < 1.00$ <div style="border: 1px solid black; padding: 2px; display: inline-block;">Section is satisfactory</div>

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✓ $\phi < \frac{M}{M_c}$

EXCLUSIVE: Just in Edutruth only

PROB #11-11

Using a W12X136 ($A = 39.9 \text{ in}^2$, $I_x = 1240 \text{ in}^4$, $\phi_b M_{px} = 803 \text{ ft-k}$,
 $\frac{M_{px}}{\Omega_b} = 534 \text{ ft-k}$, $L_p = 11.2 \text{ ft}$, $L_r = 63.3 \text{ ft}$, $BF = 6.03$
 for LRFD, $BF = 4.01$ for ASD)

LRFD	ASD
$P_u = P_n = 700 \text{ k}$ $M_{ux} = M_{nx} = 160 \text{ ft-k}$ $K_x L_x = K_y L_y = (1.0)(16) = 16 \text{ ft}$ $P_c = \phi_c P_n = 1370 \text{ k}$ (AISC Table 4-1) $\frac{P_u}{P_c} = \frac{700}{1370} = 0.511 > 0.2$ \therefore Must use AISC Eq. H1-1a $C_m = 0.6 - 0.4 \frac{M_1}{M_2} = 0.6 - 0.4 \left(\frac{160}{160} \right) = 0.2$ $P_{el} = \frac{\pi^2 E I_x}{(K_x L_x)^2} = \frac{(3^2)(29 \times 10^3)(1240)}{(12 \times 16)^2}$ $= 9628 \text{ k}$ $B_1 = \frac{C_m}{1 - \frac{P_u}{P_{el}}} = \frac{0.2}{1 - \frac{(1.0)(700)}{9628}} = \text{Say } 1.0$ $M_{ux} = B_1 M_n = (1.0)(160) = 160 \text{ ft-k}$ Since $L_b = 16 \text{ ft} > L_p = 11.2 \text{ ft} < L_r$ $\phi_b M_{mx} = 1.0 [803 - 6.03(16 - 11.2)]$ $= 774.1 \text{ ft-k}$ $\frac{P_u}{P_c} + \frac{8}{9} \left(\frac{M_{ux}}{M_{cx}} + \frac{M_{uy}}{M_{cy}} \right)$ $= \frac{700}{1370} + \frac{8}{9} \left(\frac{160}{774.1} \right) = 0.695 < 1.0$ <div style="border: 1px solid black; padding: 5px; width: fit-content;">Section is satisfactory</div>	$P_a = P_n = 420 \text{ k}$ $M_{ax} = M_{nx} = 100 \text{ ft-k}$ $K_x L_x = K_y L_y = (1.0)(16) = 16 \text{ ft}$ $P_c = \frac{P_n}{\Omega_c} = 913$ (AISC Table 4-1) $\frac{P_a}{P_c} = \frac{420}{913} = 0.460 > 0.2$ \therefore Must use AISC Eq. H1-1a $C_m = 0.6 - 0.4 \frac{M_1}{M_2}$ $= 0.6 - 0.4 \left(\frac{100}{100} \right) =$ $P_{el} = \frac{\pi^2 E I_x}{(K_x L_x)^2} = \frac{(\pi^2)(29 \times 10^3)(1240)}{(12 \times 16)^2}$ $= 9628 \text{ k}$ $B_1 = \frac{C_m}{1 - \frac{P_a}{P_{el}}} = \frac{0.2}{1 - \frac{(1.0)(420)}{9628}} = \text{Say } 1.0$ $M_{ax} = B_1 M_n = (1.0)(100) = 100 \text{ ft-k}$ Since $L_b = 16 \text{ ft} > L_p = 11.2 \text{ ft} < L_r$ $\frac{M_{mx}}{\Omega_b} = 1.0 [534 - 4.01(16 - 11.2)]$ $= 514.7 \text{ ft-k}$ $\frac{P_a}{P_c} + \frac{8}{9} \left(\frac{M_{ax}}{M_{cx}} + \frac{M_{ay}}{M_{cy}} \right)$ $= \frac{420}{913} + \frac{8}{9} \left(\frac{100}{514.7} \right) = 0.623 < 1.0$ <div style="border: 1px solid black; padding: 5px; width: fit-content;">Section is satisfactory</div>

EXCLUSIVE: Just in Edutruth only

PROB# 11-12

Using a W10x49 ($A = 14.4 \text{ in.}^2$, $I_x = 272 \text{ in.}^4$, $\phi_b M_{px} = 227 \text{ ft-k}$,

$\frac{M_{px}}{\Omega_b} = 151 \text{ ft-k}$, $L_p = 8.97 \text{ ft}$, $L_R = 31.6 \text{ ft}$, BF for LRFD = 3.67 k,

BF for ASD = 2.44 k)

LRFD	ASD
$P_n = P_u = 300 \text{ k}$ $M_{nx} = M_{ux} = \left(\frac{2}{12}\right)(300) = 50 \text{ ft-k}$ $K_y L_y = (1)(12) = 12 \text{ ft}$ $K_x L_x = (1.4)(12) = 16.8$; $\frac{K_x L_x}{r_x} = \frac{16.8}{1.71} = 9.82$ $P_c = \phi_c P_m = 513 \text{ k}$ (AISC Table 4-1) $\frac{P_n}{P_c} = \frac{300}{513} = 0.585 > 0.2$ \therefore Must use AISC Eq. H1-1a $C_m = 0.6 - 0.4 \left(-\frac{50}{50}\right) = 1.00$ $P_{el} = \frac{\pi^2 E I_x}{(K_x L_x)^2} = \frac{(\pi^2)(29 \times 10^3)(272)}{(12 \times 9.82)^2}$ $= 5606 \text{ k}$ $B_1 = \frac{C_m}{1 - \frac{\alpha P_n}{P_{el}}} = \frac{1.0}{1 - \frac{(1.0)(300)}{5606}} = 1.06$ $M_{nx} = (1.06)(50) = 53 \text{ ft-k}$ Since $L_b = 12 \text{ ft} > L$ $\phi M_{nx} = 1.0 [227 - 3.67(12 - 8.97)]$ $= 215.9 \text{ ft-k}$ $\frac{P_n}{P_c} + \frac{8}{9} \left(\frac{M_{nx}}{M_{cx}} + \frac{M_{ny}}{M_{cy}} \right)$ $= \frac{300}{513} + \left(\frac{8}{9} \right) \left(\frac{53}{215.9} + 0 \right)$ $= 0.803 < 1.0 \quad \text{OK}$ <u>Section is satisfactory</u>	$P_n = P_a = 200 \text{ k}$ $M_{nx} = M_{ax} = \left(\frac{2}{12}\right)(200) = 33.3 \text{ ft-k}$ $K_y L_y = (1)(12) = 12 \text{ ft}$ $K_x L_x = (1.4)(12) = 16.8$; $\frac{K_x L_x}{r_x} = \frac{16.8}{1.71} = 9.82$ $P_c = \frac{P_n}{\Omega_c} = 341 \text{ k}$ (AISC Table 4-1) $\frac{P_n}{P_c} = \frac{200}{341} = 0.58 > 0.2$ \therefore Must use AISC Eq. H1-1a $C_m = 0.6 - 0.4 \left(-\frac{33.3}{33.3}\right) = 1.00$ $P_{el} = \frac{\pi^2 E I_x}{(K_x L_x)^2} = \frac{(\pi^2)(29 \times 10^3)(272)}{(12 \times 9.82)^2}$ $= 5606 \text{ k}$ $B_1 = \frac{C_m}{1 - \frac{(1.0)(200)}{5606}} = 1.06$ $M_{nx} = (1.06)(33.3) = 35.3 \text{ ft-k}$ Since $L_b = 12 \text{ ft} > L_p = 8.97 \text{ ft} < L_R = 31.6$ $\phi M_{nx} = 1.0 [151 - 2.44(12 - 8.97)]$ $= 143.6 \text{ ft-k}$ $\frac{P_n}{P_c} + \frac{8}{9} \left(\frac{M_{nx}}{M_{cx}} + \frac{M_{ny}}{M_{cy}} \right)$ $= \frac{200}{341} + \left(\frac{8}{9} \right) \left(\frac{35.3}{143.6} + 0 \right)$ $= 0.805 < 1.0 \quad \text{OK}$ <u>Section is satisfactory</u>

EXCLUSIVE: Just in Edutruth only

PROB# 11-13

Using a W12x40 ($A = 11.7 \text{ in.}^2$, $I_x = 307 \text{ in.}^4$, $\phi_b M_{px} = 214 \text{ ft-k}$,

$\frac{M_{px}}{\Omega_b} = 142 \text{ ft-k}$, $L_p = 6.85 \text{ ft}$, $L_1 = 21.1 \text{ ft}$, BF for LRFD = 5.308,

BF for ASD = 3.66 k)

LRFD	ASD
$P_L = P_u = 240 \text{ k}$	$P_L = P_u = 150 \text{ k}$
$M_L = M_u = \frac{(25)(16)}{4} = 100 \text{ ft-k}$	$M_L = M_u = \frac{(15)(16)}{4} = 60 \text{ ft-k}$
$K_x L_x = (0.65)(16) = 10.4 \text{ ft}$	$K_x L_x = (0.65)(16) = 10.4 \text{ ft}$
$K_y L_y = (0.8)(8) = 6.4 \text{ ft}$	$K_y L_y = (0.8)(8) = 6.4 \text{ ft}$
$\frac{K_x L_x}{r_x} = \frac{(12)(10.4)}{5.13} = 24.33$	$\frac{K_x L_x}{r_x} = \frac{(12)(10.4)}{5.13} = 24.33$
$\frac{K_y L_y}{r_y} = \frac{(12)(6.4)}{1.94} = 39.59 \leftarrow$	$\frac{K_y L_y}{r_y} = \frac{(12)(6.4)}{1.94} = 39.59 \leftarrow$
$P_c = \phi_c P_n = 469.4 \text{ k}$	$P_c = \frac{P_n}{\Omega_c} = 312.2 \text{ k}$
$\frac{P_L}{P_c} = \frac{240}{469.4} = 0.511 > 0.2$	$\frac{P_L}{P_c} = \frac{150}{312.2} = 0.481 > 0.2$
\therefore Must use AISC Eq. H1-1a	\therefore Must use AISC Eq. H1-1a
$P_{e1} = \frac{\pi^2 E I_x}{(K L)^2} = \frac{(\pi^2)(29 \times 10^3)(307)}{(12 \times 10.4)^2}$	$P_{e1} = \frac{\pi^2 E I_x}{(K L)^2} = \frac{(\pi^2)(29 \times 10^3)(307)}{(12 \times 10.4)^2}$
$= 564.2 \text{ k}$	$= 564.2 \text{ k}$
$C_{mx} = 1 - 0.2 \frac{P_u}{P_{e1}} = 1 - 0.2 \left(\frac{250}{564.2} \right)$	$C_{mx} = 1 - 0.2 \frac{P_u}{P_{e1}} = 1 - 0.2 \left(\frac{150}{564.2} \right) = 0.995$
$= 0.991$	
$B_{1x} = \frac{C_{mx}}{1 - \alpha \frac{P_u}{P_{e1}}} = \frac{0.991}{1 - (1.0) \left(\frac{250}{564.2} \right)}$	$B_{1x} = \frac{C_{mx}}{1 - \alpha \frac{P_u}{P_{e1}}} = \frac{0.995}{1 - (1.0) \left(\frac{150}{564.2} \right)}$
$= 1.035$	$= 1.039$

EXCLUSIVE: Just in Edutruth only

PROB#11-13 CONTD.

L RFD	ASD
$M_{2x} = (1.035)(100) = 103.5 \text{ ft-k}$ $L_b = 8 \text{ ft} > L_p = 6.85 \text{ ft} < L_{2x} = 21.1 \text{ ft}$ $C_b = \frac{12.5 M_{\max}}{2.5 M_{\max} + 3M_A + 4M_B + 3M_C} \rightarrow R_m < 3.0$ $= \frac{(12.5)(100)}{(2.5)(100) + (3)(0) + (4)(0) + (3)(0)} R_m$ $= 1.923 R_m = (1.923)(1.0) = 1.923$ $\phi_b M_{px} = 1.923 [214 - (5.5)(16 - 6.85)]$ $= 314.7 \text{ ft-k}$ $\frac{P_x}{P_c} + \frac{8}{9} \left(\frac{M_{2x}}{M_{cx}} + \frac{M_{2y}}{M_{cy}} \right)$ $= \frac{240}{469.4} + \left(\frac{8}{9} \right) \left(\frac{103.5}{314.7} + 0 \right)$ $= 0.729 < 1.00$ <u>ok but</u> <u>over designed</u>	$M_{2x} = (1.039)(60) = 62.34 \text{ ft-k}$ $L_b = 8 \text{ ft} > L_p = 6.85 \text{ ft} < L_{2x} = 21.1 \text{ ft}$ $C_b = \frac{12.5 M_{\max}}{2.5 M_{\max} + 3M_A + 4M_B + 3M_C} \rightarrow R_m < 3.0$ $= \frac{(12.5)(60)}{(2.5)(60) + (3)(0) + (4)(0) + (3)(0)} R_m$ $= 1.923 R_m = (1.923)(1.0) = 1.923$ $\frac{M_{px}}{\Omega_b} = 1.923 [142 - 3.66(16 - 6.85)]$ $= 208.7 \text{ ft-k}$ $\frac{P_x}{P_c} + \frac{8}{9} \left(\frac{M_{2x}}{M_{cx}} + \frac{M_{2y}}{M_{cy}} \right)$ $= \frac{150}{312.2} + \frac{8}{9} \left(\frac{62.4}{208.7} + 0 \right)$ $= 0.677 < 1.0$ <u>ok but</u> <u>over designed</u>

✓ $\phi < \phi_c$

EXCLUSIVE: Just in Edutruth only

PROB # 11-14

Using a W12x40 ($A = 11.7 \text{ in.}^2$, $I_x = 307 \text{ in.}^4$, $\phi_b M_{px} = 214 \text{ ft-k}$,
 $\frac{M_{px}}{\Omega_b} = 142 \text{ ft-k}$, $L_p = 6.85 \text{ ft}$, $L_r = 21.1 \text{ ft}$, BF for LRFD = 5.50 k,
 BF for ASD = 3.66 k)

LRFD	ASD
$P_u = P_u = 240 \text{ k}$ $M_u = M_u = \frac{(25)(16)}{4} = 100 \text{ ft-k}$ $K_x L_x = (1)(16) = 16 \text{ ft}$ $K_y L_y = (1)(8) = 8 \text{ ft}$ $\frac{K_x L_x}{r_x} = \frac{(12)(16)}{5.13} = 37.43$ $\frac{K_y L_y}{r_y} = \frac{(12)(8)}{1.94} = 49.48 \leftarrow$ $P_c = \phi_c P_n = 439 \text{ k}$ $\frac{P_u}{P_c} = \frac{240}{439} = 0.547 > 0.2$ \therefore Must use AISC Eq. H1-1a $P_{el} = \frac{\pi^2 EI_x}{(KL)^2} = \frac{(\pi^2)(29 \times 10^3)(307)}{(12 \times 16)^2} = 2384 \text{ k}$ $C_{mx} = 1 - 0.2 \frac{P_u}{P_{el}} = 1 - 0.2 \frac{240}{2384} = 0.979$ $B_{1x} = \frac{C_{mx}}{1 - \frac{P_u}{P_{el}}} = \frac{0.979}{1 - \frac{(1.0)(240)}{2384}} = 1.094$ $C_b = \frac{12.5 M_{max}}{2.5 M_{max} + 3 M_A + 4 M_B + 3 M_C} (R_m)$ $= \frac{(12.5)(100)}{(2.5)(100) + (3)(50) + (4)(100) + (3)(50)} (1.0)$ $= 1.316$	$P_a = P_a = 150 \text{ k}$ $M_a = M_a = \frac{(15)(16)}{4} = 60 \text{ ft-k}$ $K_x L_x = (1)(16) = 16 \text{ ft}$ $K_y L_y = (1)(8) = 8 \text{ ft}$ $\frac{K_x L_x}{r_x} = \frac{12 \times 16}{5.13} = 37.43$ $\frac{K_y L_y}{r_y} = \frac{12 \times 8}{1.94} = 49.48 \leftarrow$ $P_c = \frac{P_n}{\Omega_c} = 292 \text{ k}$ $\frac{P_a}{P_c} = \frac{150}{292} = 0.514 > 0.2$ \therefore Must use AISC Eq. H1-1a $P_{el} = \frac{\pi^2 EI_x}{(KL)^2} = \frac{(\pi^2)(29 \times 10^3)(307)}{(12 \times 16)^2} = 2384 \text{ k}$ $C_{mx} = 1 - 0.2 \frac{P_a}{P_{el}} = 1 - 0.2 \frac{150}{2384} = 0.987$ $B_{1x} = \frac{C_{mx}}{1 - \frac{P_a}{P_{el}}} = \frac{0.987}{1 - \frac{(1.0)(150)}{2384}} = 1.097$ $C_b = \frac{12.5 M_{max}}{2.5 M_{max} + 3 M_A + 4 M_B + 3 M_C} (R_m)$ $= \frac{(12.5)(60)}{(2.5)(60) + (3)(30) + (4)(60) + (3)(30)} (1.0)$ $= 1.316$

EXCLUSIVE: Just in Edutruth only

PROB #11-14 CONTD.

LAFD	ASD
$\phi_b M_{px} = 1.316 [214 - (5.5)(16 - 6.85)]$ $= 215.4 \text{ ft-k}$ $\frac{P_u}{\phi_c} + \frac{8}{9} \left(\frac{M_{ux}}{\phi_{bx}} + \frac{M_{uy}}{\phi_{by}} \right)$ $= \frac{293}{439} + \frac{8}{9} \left(\frac{1.094 \times 100}{215.4} \right)$ $= 0.998 < 1.00 \quad \underline{\text{OK}}$ <div style="border: 1px solid black; padding: 5px; display: inline-block;"> \therefore section is satisfactory </div>	$\frac{M_{px}}{\phi_b} = 1.316 [142 - (5.66)(16 - 6.85)]$ $= 142.8 \text{ ft-k}$ $\frac{P_u}{\phi_c} + \frac{8}{9} \left(\frac{M_{ux}}{\phi_{bx}} + \frac{M_{uy}}{\phi_{by}} \right)$ $= \frac{150}{292} + \frac{8}{9} \left(\frac{1.097 \times 60}{142.8} \right)$ $= 0.923 < 1.00 \quad \underline{\text{OK}}$ <div style="border: 1px solid black; padding: 5px; display: inline-block;"> \therefore Section is satisfactory </div>

✓ J.C.M.

EXCLUSIVE: Just in Edutruth only

PROB #11-15

$$KL = (1)(12) = 12 \text{ ft}$$

LRFD	ASD
$P_{ueq} = P_u + M_{ux}m + M_{uy}m_u$ From 1st Approximation part of Table 11-2 in this chapter $m = 1.8$ for $KL = 12 \text{ ft}$ and $F_y = 50$ $P_{ueq} = 800 + (160)(1.8) + (60)(1.8)(2.0)$ $= 1304 \text{ k}$ Now deciding to use W12 From subsequent approximation part of table $m = 1.6$ $P_{ueq} = 800 + (160)(1.6) + (60)(1.6)(2.0)$ $= 1248 \text{ k}$ <u>TRY W12x120 ($\phi_c P_n = 1360 \text{ k}$)</u>	$P_{aeq} = P_a + M_{ax}m + M_{ay}m_u$ From 1st Approximation part of Table 11-2 in this chapter $m = 1.8$ for $KL = 12 \text{ ft}$ and $F_y = 50$ $P_{aeq} = 500 + (100)(1.8) + (40)(1.8)(2.0)$ $= 824 \text{ k}$ Now deciding to use W12 From subsequent approximation part of table $m = 1.6$ $P_{aeq} = 500 + (100)(1.6) + (40)(1.6)(2.0)$ $= 788 \text{ k}$ <u>TRY W12x106 ($\frac{P_n}{\phi_c} = 798 \text{ k}$)</u>

✓ JCM

EXCLUSIVE: Just in Edutruth only

PROB# 11-16

$$KL = (1)(12) = 12 \text{ ft}$$

LRFD	ASD
$P_{ueq} = P_u + M_{ux}m + M_{uy}m_u$ From 1st Approximation part of Table 11-2 in this chapter $m = 1.8$ for $KL = 12 \text{ ft}$, $F_y = 50 \text{ ksi}$ $P_{ueq} = 800 + (160)(1.8) + (60)(1.8)(2.0)$ $= 1304 \text{ k}$ Now deciding to use W14 From subsequent approximation part of table $m = 1.4$ $P_{ueq} = 800 + (160)(1.4) + (60)(1.4)(2.0)$ $= 1192 \text{ k}$ <u>TRY W14 x 109 ($\phi_c P_n = 1290 \text{ k}$)</u>	$P_{ueq} = P_u + M_{ux}m + M_{uy}m_u$ From 1st Approximation part of Table 11-2 in this chapter $m = 1.8$ for $KL = 12 \text{ ft}$ and $F_y = 50 \text{ ksi}$ $P_{ueq} = 500 + (100)(1.8) + (40)(1.8)(2.0)$ $= 824 \text{ k}$ Now deciding to use W14 From subsequent approximation part of table $m = 1.4$ $P_{ueq} = 500 + (100)(1.4) + (40)(1.4)(2.0)$ $= 752 \text{ k}$ <u>TRY W14 x 99 ($\frac{P_n}{\Omega_c} = 781 \text{ k}$)</u>

✓ gcm

EXCLUSIVE: Just in Edutruth only

PROB #11-17

$$KL = (1)(14) = 14 \text{ ft}$$

LRFD	ASD
$P_{ueq} = P_u + M_{ux}m + M_{uy}m\mu$ From 1st approximation part of Table 11-2 in this chapter $m = 1.7$ for $KL = 14 \text{ ft}$ and $F_y = 50$ $P_{ueq} = 800 + (1.7)(320) + 0 = 1344 \text{ k}$ Now deciding to use W12 $m = 1.5$ $P_{ueq} = 800 + (1.5)(320) = 1280 \text{ k}$ <u>TRY W12X120 ($\phi_t P_n = 1290 \text{ k}$)</u>	$P_{ueq} = P_u + M_{ux}m + M_{uy}m\mu$ From 1st approximation part of Table 11-2 in this chapter $m = 1.7$ for $KL = 14 \text{ ft}$ and $F_y = 50$ $P_{ueq} = 500 + (1.7)(200) + 0 = 840 \text{ k}$ Now deciding to use W12 $m = 1.5$ $P_{ueq} = 500 + (1.5)(200) = 800 \text{ k}$ <u>TRY W12X120 ($\frac{P_u}{\phi_c} = 856 \text{ k}$)</u>

✓ JCMC

EXCLUSIVE: Just in Edutruth only

PROB#11-18

$$KL = (0.65)(20) = 13 \text{ ft}$$

LRFD	ASD
$P_{ueq} = P_u + M_{ux} m + M_{uy} m_u$ From 1st Approximation part of Table 11-2 in this chapter $m = \frac{1.8+1.7}{2} = 1.75$ for KL of 13 ft with $F_y = 50 \text{ ksi}$ $P_{ueq} = 250 + (180)(1.75) + (80)(1.75)(2.0)$ $= 845 \text{ k}$ Now deciding to use a W12 $m = \frac{1.6+1.5}{2} = 1.55$ $P_{ueq} = 250 + (180)(1.55) + (80)(1.55)(2.0)$ $= 777 \text{ k}$ <u>TRY W12X72 ($\phi_c P_n = 784 \text{ k}$)</u>	$P_{aeq} = P_a + M_{ax} m + M_{ay} m_u$ From 1st Approximation part of Table 11-2 in this chapter $m = \frac{1.8+1.7}{2} = 1.75$ for KL of 13 ft with $F_y = 50 \text{ ksi}$ $P_{aeq} = 150 + (110)(1.75) + (50)(1.75)(2.0)$ $= 517.5 \text{ k}$ Now deciding to use a W12 $m = \frac{1.6+1.5}{2} = 1.55$ $P_{aeq} = 150 + (110)(1.55) + (50)(1.55)(2.0)$ $= 475.5 \text{ k}$ <u>TRY W12X72 ($\frac{P_m}{\phi_c} = 522 \text{ k}$)</u>

✓ JCMC

EXCLUSIVE: Just in Edutruth only

PROB# 11-19

$$KL = (0.65)(24) = 15.6 \text{ ft}$$

LRFD	ASD
$P_{ueq} = P_u + M_{ux}m + M_{uy}m_u$ From 1st Approximation part of Table 11-2 in this chapter $m = 1.7 + \left(\frac{1.6}{2}\right)(-0.1) = 1.62$ For $KL = 15.6 \text{ ft}$ and $F_y = 50 \text{ ksi}$ $P_{ueq} = 250 + (220)(1.62) + (80)(1.62)(2.0)$ $= 865.6 \text{ k}$ Now deciding to use a W14 $m = 1.4 + \left(\frac{1.6}{2}\right)(-0.1) = 1.32$ $P_{ueq} = 250 + (220)(1.32) + (80)(1.32)(2.0)$ $= 751.6 \text{ k}$ <u>TRY W14X90 ($\phi_c P_n = 986.8 \text{ k}$)</u>	$P_{aeq} = P_a + M_{ax}m + M_{ay}m_u$ From 1st Approximation part of Table 11-2 in this chapter $m = 1.7 + \left(\frac{1.6}{2}\right)(-0.1) = 1.62$ For $KL = 15.6 \text{ ft}$ and $F_y = 50 \text{ ksi}$ $P_{aeq} = 150 + (150)(1.62) + (50)(1.62)(2.0)$ $= 555 \text{ k}$ Now deciding to use a W14 $m = 1.4 + \left(\frac{1.6}{2}\right)(-0.1) = 1.32$ $P_{aeq} = 150 + (150)(1.32) + (50)(1.32)(2.0)$ $= 480 \text{ k}$ <u>TRY W14X82 ($\frac{P_n}{A_c} = 481 \text{ k}$)</u>

✓ gcm

EXCLUSIVE: Just in Edutruth only

PROB# 11-20

LRFD	ASD
$P_u = P_r = 400 \text{ k}$	$P_a = P_r = 250 \text{ k}$
$M_{ux} = M_{rx} = 150 \text{ ft-k}$	$M_{ax} = M_{rx} = 90 \text{ ft-k}$

Estimating a W14 section

$$P_{u\text{eq}} = P_u + M_{ux}/m + M_{uy}/m_u$$

$$= 400 + (150)(1.4) + 0 = 610 \text{ k}$$

Try W14X68 from AISC Table 4-1 ($A = 20 \text{ in}^2$, $d = 14.0 \text{ in}$,
 $I_x = 722 \text{ in}^4$)

Checking the section

LRFD	ASD
$P_{e1} = \frac{\pi^2 EI_x}{(KL)_x^2} = \frac{(\pi^2)(29 \times 10^3)(722)}{(12 \times 14)^2}$ $= 7322 \text{ k}$	$P_{e1} = \frac{\pi^2 EI_x}{(KL)_x^2} = \frac{(\pi^2)(29 \times 10^3)(722)}{(12 \times 14)^2}$ $= 7322 \text{ k}$
$B_1 = \frac{C_m}{1 - \frac{\alpha P_u}{P_{e1}}} = \frac{1.0}{1 - \frac{(1.0)(400)}{7322}}$ $= 1.06$	$B_1 = \frac{1.0}{1 - \frac{(1.6)(250)}{7322}}$ $= 1.06$
$B_1 M_{ux} = (1.06)(150) = 159 \text{ ft-k}$	$B_1 M_{ax} = (1.06)(90) = 95.4 \text{ ft-k}$
From AISC Table 6-1	From AISC Table 6-1
$\rho = 1.56 \times 10^{-3}$	$\rho = 2.35 \times 10^{-3}$
$b_x = 2.28 \times 10^{-3}$	$b_x = 3.43 \times 10^{-3}$
$b_y = 6.42 \times 10^{-3}$	$b_y = 9.65 \times 10^{-3}$

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EXCLUSIVE: Just in Edutruth only

PROB# 11-20 CONTD.

LRFD	ASD
<p>Using Modified AISC Eqs. <u>H1-1a or H1-1b</u></p> $\frac{P_u}{P_c} = \frac{400}{639} > 0.2$ <p>∴ Must use H1-1a</p> $\phi P_u + b_x M_{ux} + b_y M_{uy} \leq 1.0$ $(1.56 \times 10^{-3})(400) + (2.28 \times 10^{-3})(159)$ $= 0.986 < 1.00 \quad \underline{\text{OK}}$ <div style="border: 1px solid black; padding: 2px; display: inline-block;">USE W14X68</div>	<p>Using Modified AISC Eqs. <u>H1-1a or H1-1b</u></p> $\frac{P_u}{P_c} = \frac{250}{425} > 0.2$ <p>∴ Must use H1-1a</p> $\phi P_u + b_x M_{ux} + b_y M_{uy} \leq 1.0$ $(2.35 \times 10^{-3})(250) + (3.43 \times 10^{-3})(95.4)$ $= 0.915$ <div style="border: 1px solid black; padding: 2px; display: inline-block;">USE W14X68</div>

✓ JCM

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EXCLUSIVE: Just in Edutruth only

PROB # 11-21

LRFD	ASD
$P_u = P_n = 400 \text{ k}$ $M_{ux} = M_{nx} = 150 \text{ ft-k}$	$P_a = P_n = 250 \text{ k}$ $M_{ax} = M_{nx} = 90 \text{ ft-k}$

Estimating a W12 section

$$P_{u \text{ eq.}} = P_u + M_{ux} m + M_{uy} m_u$$

$$= 400 + (150)(1.4) + 0 = 610 \text{ k}$$

From AISC Table 4-1 Try W12X65 ($I_x = 533 \text{ in.}^4$)

Checking the section

LRFD	ASD
$P_{e1} = \frac{\pi^2 E I_x}{(KL)_x^2} = \frac{(\pi^2)(29 \times 10^3)(533)}{(12 \times 14)^2}$ $= 5405 \text{ k}$ $B_1 = \frac{C_m}{1 - \alpha \frac{P_u}{P_{e1}}} = \frac{1.0}{1 - \frac{(1.0)(400)}{5405}}$ $= 1.08$ $B_1 M_{ux} = (1.08)(150) = 162 \text{ ft-k}$ <p><u>From AISC Table 6-1</u></p> $p = 1.46 \times 10^{-3}$ $b_x = 2.58 \times 10^{-3}$ $b_y = 5.53 \times 10^{-3}$	$P_{e1} = \frac{\pi^2 E I_x}{(KL)_x^2} = \frac{(\pi^2)(29 \times 10^3)(533)}{(12 \times 14)^2}$ $= 5405 \text{ k}$ $B_1 = \frac{C_m}{1 - \alpha \frac{P_a}{P_{e1}}} = \frac{1.0}{1 - \frac{(1.0)(250)}{5405}}$ $= 1.08$ $B_1 M_{ux} = (1.08)(90) = 97.2 \text{ ft-k}$ <p><u>From AISC Table 6-1</u></p> $p = 2.19 \times 10^{-3}$ $b_x = 3.87 \times 10^{-3}$ $b_y = 8.31 \times 10^{-3}$

EXCLUSIVE: Just in Edutruth only

PROB # 11-21 CONTD.

LRFD	ASD
P_c from AISC Table 4-1 = 685 k $\frac{P_u}{P_c} = \frac{400}{685} = 0.584 > 0.2$ \therefore Must use Modified AISC <u>Formula H1-1a</u> $P_u + b_x M_{ux} + b_y M_{uy} \leq 1.0$ $(1.46 \times 10^{-3})(400) + (2.58 \times 10^{-3})(162) + 0$ $= 1.002 \approx 1.00 \quad \underline{\text{OK}}$	P_c from AISC Table 4-1 = 456 k $\frac{P_u}{P_c} = \frac{250}{456} = 0.548 > 0.2$ \therefore Must use Modified AISC <u>Formula H1-1a</u> $P_u + b_x M_{ux} + b_y M_{uy} \leq 1.0$ $= (2.19 \times 10^{-3})(250) + (3.87 \times 10^{-3})(972) + 0$ $= 0.924 < 1.00 \quad \underline{\text{OK}}$
USE W12X65	USE W12X65

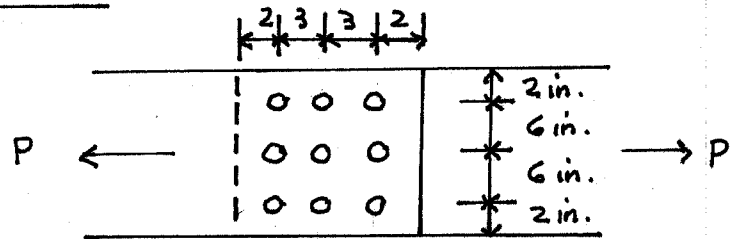
✓ g c m =

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EXCLUSIVE: Just in Edutruth only

CHAPTER 12

PROB #12-1



(a) Gross section yielding
of PLs

$$P_m = F_y A_g = (36)(1 \times 16) = 576 \text{ k}$$

LRFD $\phi_t = 0.90$	ASD $\Omega_t = 1.67$
$\phi_t P_m = (0.90)(576) = 518.4 \text{ k}$	$\frac{P_m}{\Omega_t} = \frac{576}{1.67} = 344.9 \text{ k}$

(b) Tensile rupture strength of PLs

$$A_n = 16.00 - (3)\left(\frac{3}{4} + \frac{1}{8}\right)(1.0) = 13.375 \text{ in.}^2$$

$U = 1.0$ as all parts connected

$$P_m = F_u A_n = (58)(13.375)(1.0) = 775.75 \text{ k}$$

LRFD $\phi_t = 0.75$	ASD $\Omega_t = 2.00$
$\phi_t P_m = (0.75)(775.75) = 581.8 \text{ k}$	$\frac{P_m}{\Omega_t} = \frac{775.75}{2.00} = 387.9 \text{ k}$

(c) Bearing strength of bolts

$$L_c = \text{lesser of } 2 - \frac{1}{2}\left(\frac{3}{4} + \frac{1}{8}\right) \text{ or } 3 - \left(\frac{3}{4} + \frac{1}{8}\right) = 1.5625 \text{ in.}$$

$$R_m = 1.2 L_c \leq F_u (N_o \text{ of bolts}) \leq 2.4 d \leq F_u (N_o \text{ of bolts})$$

$$R_m = (1.2)(1.5625)(1.0)(58)(9) = 978.8 \text{ k} > (2.4)\left(\frac{3}{4}\right)(1)(58)(9) = \underline{939.6 \text{ k}}$$

LRFD $\phi = 0.75$	ASD $\Omega = 2.00$
$\phi R_m = (0.75)(939.6) = 704.7 \text{ k}$	$\frac{R_m}{\Omega} = \frac{939.6}{2.00} = 469.8 \text{ k}$

(d) Shearing strength of bolts

$$R_m = F_n A_b = (60)(0.44)(9) = 237.6 \text{ k}$$

LRFD $\phi = 0.75$	ASD $\Omega = 2.00$
$\phi R_m = (0.75)(237.6) = \underline{178.2 \text{ k}}$	$\frac{R_m}{\Omega} = \frac{237.6}{2.00} = \underline{118.8 \text{ k}}$

ANSWERS

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EXCLUSIVE: Just in Edutruth only

PROB #12-2

SKETCH SAME AS FOR PROB. #12-1

(a) Gross section yielding of PLS

$$P_m = F_y A_g = (36)(1 \times 16) = 576 \text{ k}$$

LRFD $\phi_t = 0.90$	ASD $\Omega_t = 1.67$
$\phi_t P_m = (0.9)(576) = 518.4 \text{ k}$	$\frac{P_m}{\Omega_t} = \frac{576}{1.67} = 344.9 \text{ k}$

(b) Tensile rupture strength of PLS

$$A_n = 16 - (3)(1 + \frac{1}{8}) = 12.625 \text{ in.}^2$$

$U = 1.0$ as all parts connected

$$P_m = F_u A_n = (58)(12.625 \times 1.0) = 732.25 \text{ k}$$

LRFD $\phi_t = 0.75$	ASD $\Omega_t = 2.00$
$\phi_t P_m = (0.75)(732.25) = 549.2 \text{ k}$	$\frac{P_m}{\Omega_t} = \frac{732.25}{2.00} = 366.1 \text{ k}$

(c) Bearing strength of bolts

$$L_c = \text{lesser of } 2 - \frac{1.125}{2} \text{ or } 3 - 1.125 = 1.4375 \text{ in.}$$

$$R_m = 1.2 L_c \leq F_u (\text{No of bolts}) \leq 2.4 d \leq F_u (\text{No of bolts})$$

$$R_m = (1.2)(1.4375)(1)(58)(9) = 900.45 \text{ k} < (2.4)(1)(1)(58)(9) = 1252.8 \text{ k}$$

LRFD $\phi = 0.75$	ASD $\Omega = 2.00$
$\phi R_m = (0.75)(900.45) = 675.3 \text{ k}$	$\frac{R_m}{\Omega} = \frac{900.45}{2.00} = 450.2 \text{ k}$

(d) Shearing strength of bolts

$$R_m = F_u A_b = (60)(0.785)(9) = 423.9 \text{ k}$$

LRFD $\phi = 0.75$	ASD $\Omega = 2.00$
$\phi R_m = (0.75)(423.9) = 317.9 \text{ k}$	$\frac{R_m}{\Omega} = \frac{423.9}{2.00} = 211.9 \text{ k}$

ANSWERS

317.9 k LRFD

211.9 k ASD

✓ $\phi < m$

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EXCLUSIVE: Just in Edutruth only

PROB# 12-3

SKETCH SAME AS FOR PROB#12-1

(a) Gross section yielding of PLS

$$P_m = F_y A_g = (36)(1 \times 16) = 576 \text{ k}$$

LRFD $\phi_t = 0.90$	ASD $\Omega_t = 1.67$
$\phi_t P_m = (0.90)(576) = 518.4 \text{ k}$	$\frac{P_m}{\Omega_t} = \frac{576}{1.67} = 344.9 \text{ k}$

(b) Tensile rupture strength of PLS

$$A_m = 16.00 - (3)\left(\frac{7}{8} + \frac{1}{8}\right) = 13.00 \text{ in.}^2$$

$u = 1.0$ as all parts connected

$$P_m = F_u A_e = (58)(13.00)(1.0) = 754 \text{ k}$$

LRFD $\phi_t = 0.75$	ASD $\Omega_t = 2.00$
$\phi_t P_m = (0.75)(754) = 565.5 \text{ k}$	$\frac{P_m}{\Omega_t} = \frac{754}{2.00} = 377 \text{ k}$

(c) Bearing strength of bolts

$$L_c = \text{lesser of } 2 - \frac{1}{2}\left(\frac{7}{8} + \frac{1}{8}\right) = 1.50 \text{ in. or } 3 - \left(\frac{7}{8} + \frac{1}{8}\right) = 2.00 \text{ in.}$$

$$R_m = 1.2 L_c \leq F_u (\text{No of bolts}) \geq 2.4 d \leq F_u (\text{No of bolts})$$

$$R_m = (1.2)(1.50)(1.0)(58)(9) = 939.6 \text{ k} < (2.4)\left(\frac{7}{8}\right)(1.0)(58)(9) = 1096.2 \text{ k}$$

LRFD $\phi = 0.75$	ASD $\Omega = 2.00$
$\phi R_m = (0.75)(939.6) = 704.7 \text{ k}$	$\frac{R_m}{\Omega} = \frac{939.6}{2.00} = 469.8 \text{ k}$

(d) Shearing strength of bolts

$$R_m = F_n A_b = (48)(0.60)(9) = 259.2 \text{ k}$$

LRFD $\phi = 0.75$	ASD $\Omega = 2.00$
$\phi R_m = (0.75)(259.2) = 194.4 \text{ k}$	$\frac{R_m}{\Omega} = \frac{259.2}{2.00} = 129.6 \text{ k}$

ANSWERS.

194.4 k LRFD

129.6 k ASD

EXCLUSIVE: Just in Edutruth only

PROB#12-4

SKETCH SAME AS FOR PROB #12-1

(a) Gross section yielding of PLs

$$P_m = F_y A_g = (36)(1 \times 16) = 576 \text{ k}$$

LRFD $\phi_t = 0.90$	ASD $\Omega_t = 1.67$
$\phi_t P_m = (0.90)(576) = 518.4 \text{ k}$	$\frac{P_m}{\Omega_t} = \frac{576}{1.67} = 344.9 \text{ k}$

(b) Tensile rupture strength of plates

$$A_m = 16.00 - (3)\left(\frac{7}{8} + \frac{1}{8}\right) = 13.00 \text{ in.}^2$$

$u = 1.00$ as all parts connected

$$P_m = F_u A_e = (58)(13.00)(1.00) = 754 \text{ k}$$

LRFD $\phi_t = 0.75$	ASD $\Omega_t = 2.00$
$\phi_t P_m = (0.75)(754) = 565.5 \text{ k}$	$\frac{P_m}{\Omega_t} = \frac{754}{2.00} = 377 \text{ k}$

(c) Bearing strength of bolts

$$L_c = \text{lesser of } 2 - \frac{1}{2}\left(\frac{7}{8} + \frac{1}{8}\right) = 1.50 \text{ in. or } 3 - \left(\frac{7}{8} + \frac{1}{8}\right) = 2.00 \text{ in.}$$

$$R_m = 1.2 L_c \leq F_u (N_b \text{ of bolts}) = 2.4 d \leq F_u (N_b \text{ of bolts})$$

$$R_m = (1.2)(1.50)(1.0)(58)(9) = 939.6 \text{ k} < (2.4)\left(\frac{7}{8}\right)(1.0)(58)(9) = 1096.2 \text{ k}$$

LRFD $\phi = 0.75$	ASD $\Omega = 2.00$
$\phi R_m = (0.75)(939.6) = 704.7 \text{ k}$	$\frac{R_m}{\Omega} = \frac{939.6}{2.00} = 469.8 \text{ k}$

(d) Shearing strength of bolts

$$R_m = F_u A_b = (75)(0.60)(9) = 405 \text{ k}$$

LRFD $\phi = 0.75$	ASD $\Omega = 2.00$
$\phi R_m = (0.75)(405) = 303.7 \text{ k}$	$\frac{R_m}{\Omega} = \frac{405}{2.00} = 202.5 \text{ k}$

ANSWERS.

303.7 k LRFD

202.5 k ASD

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VGC MC

EXCLUSIVE: Just in Edutruth only

PROB #12-5

SKETCH SAME AS FOR PROB #12-1

(a) Gross section yielding of PLs

$$P_m = F_y A_g = (36)(1 \times 16) = 576 \text{ k}$$

LRFD $\phi_t = 0.90$	ASD $\Omega_t = 1.67$
$\phi_t P_m = (0.90)(576) = 518.4 \text{ k}$	$\frac{P_m}{\Omega_t} = \frac{576}{1.67} = 344.9 \text{ k}$

(b) Tensile rupture strength of plates

$$A_n = 16.00 - (3)\left(\frac{3}{4} + \frac{1}{8}\right)(1.0) = 13.375 \text{ in.}^2$$

$u = 1.0$ as all plates connected

$$P_m = F_u A_e = (58)(13.375)(1.0) = 775.75 \text{ k}$$

LRFD $\phi_t = 0.75$	ASD $\Omega_t = 2.00$
$\phi_t P_m = (0.75)(775.75) = 581.8 \text{ k}$	$\frac{P_m}{\Omega_t} = \frac{775.75}{2.00} = 387.9 \text{ k}$

(c) Bearing strength of bolts

$$L_c = \text{lesser of } 2 - \left(\frac{1}{2}\right)\left(\frac{3}{4} + \frac{1}{8}\right) = 1.5625 \text{ in. or } 3 - \left(\frac{3}{4} + \frac{1}{8}\right) = 3.125 \text{ in.}$$

$$R_m = 1.2 L_c \leq F_u (\text{No of bolts}) \geq 2.4 d \leq F_u (\text{No of bolts})$$

$$R_m = (1.2)(1.5625)(1.0)(58)(9) = 978.8 \text{ k} > (2.4)\left(\frac{3}{4}\right)(1)(58)(9) = 939.6 \text{ k}$$

LRFD $\phi = 0.75$	ASD $\Omega = 2.00$
$\phi R_m = (0.75)(939.6) = 704.7 \text{ k}$	$\frac{R_m}{\Omega} = \frac{939.6}{2.00} = 469.8 \text{ k}$

(d) Shearing strength of bolts

$$R_m = F_u A_b = (60)(0.44)(9) = 237.6 \text{ k}$$

LRFD $\phi = 0.75$	ASD $\Omega = 2.00$
$\phi R_m = (0.75)(237.6) = 178.2 \text{ k}$	$\frac{R_m}{\Omega} = \frac{237.6}{2.00} = 118.8 \text{ k}$

ANSWRS.

178.2 k LRFD

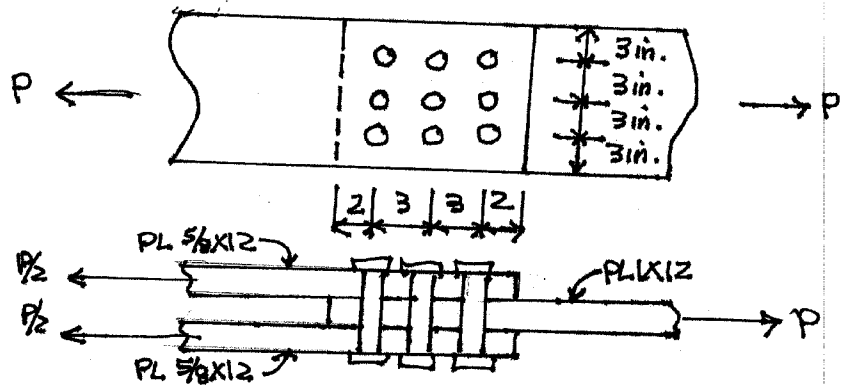
118.8 k ASD

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✓ JCM

EXCLUSIVE: Just in Edutruth only

PROB #12-6



(a) Gross section yielding of PLs

$$P_m = F_y A = (36)(1 \times 12) = 432 \text{ k}$$

LRFD $\phi_t = 0.90$	ASD $\Omega_t = 1.67$
$\phi_t P_m = (0.90)(432) = 388.8 \text{ k}$	$\frac{P_m}{\Omega_t} = \frac{432}{1.67} = 258.7 \text{ k}$

(b) Tensile rupture of plates

$$A_n = (1 \times 12) - (3)\left(\frac{3}{4} + \frac{1}{8}\right)(1) = 9.375 \text{ in.}^2$$

$$u = 1.0 \text{ as all plates connected}$$

$$P_m = F_u A_n = (58)(9.375 \times 1.0) = 543.75 \text{ k}$$

LRFD $\phi_t = 0.75$	ASD $\Omega_t = 2.00$
$\phi_t P_m = (0.75)(543.75) = 407.8 \text{ k}$	$\frac{P_m}{\Omega_t} = \frac{543.75}{2.00} = 271.9 \text{ k}$

(c) Bearing strength of bolts

$$L_c = \text{lesser of } 2 - \left(\frac{1}{2}\right)\left(\frac{3}{4} + \frac{1}{8}\right) = 1.5625 \text{ in. or } 3 - \left(\frac{3}{4} + \frac{1}{8}\right) = 2.125 \text{ in.}$$

$$R_m = 1.2 L_c \leq F_u (\text{No. of bolts}) \leq 2.4 d \leq F_u (\text{No. of bolts})$$

$$R_m = (1.2)(1.5625)(40)(58)(9) = 978.7 \text{ k} > (2.4)\left(\frac{3}{4}\right)(1)(58)(9) = 939.6 \text{ k}$$

LRFD $\phi = 0.75$	ASD $\Omega = 2.00$
$\phi R_m = (0.75)(939.6) = 704.7 \text{ k}$	$\frac{P_m}{\Omega} = \frac{939.6}{2.00} = 469.8 \text{ k}$

(d) Double shearing strength of bolts

$$R_m = F_n A_w (\text{No. of bolts}) = (60)(2)(0.44)(9) = 475.2 \text{ k}$$

LRFD $\phi = 0.75$	ASD $\Omega = 2.00$
$\phi R_m = (0.75)(475.2) = 356.4 \text{ k}$	$\frac{R_m}{\Omega} = \frac{475.2}{2.00} = 237.6 \text{ k}$

ANSWERS

356.4 k LRFD

237.6 k ASD

✓ gcm

EXCLUSIVE: Just in Edutruth only

PROB #12-7

SKETCH SAME AS FOR PROB #12-6

(a) Gross section yielding of plates

$$P_m = F_y A_g = (36)(1 \times 12) = 432 \text{ k}$$

LRFD $\phi_t = 0.90$	ASD $\Omega_t = 1.67$
$\phi_t P_m = (0.90)(432) = 388.8 \text{ k}$	$\frac{P_m}{\Omega_t} = \frac{432}{1.67} = 258.7 \text{ k}$

(b) Tensile rupture of plates

$$A_n = (1 \times 12) - (3 \times (\frac{7}{8} + \frac{1}{8}))(1.0) = 9.00 \text{ in.}^2$$

$$u = 1.0 \text{ as all plates connected}$$

$$P_m = F_u A_e = (58)(9.00 \times 1.00) = 522 \text{ k}$$

LRFD $\phi_t = 0.75$	ASD $\Omega_t = 2.00$
$\phi_t P_m = (0.75)(522) = 391.5 \text{ k}$	$\frac{P_m}{\Omega_t} = \frac{522}{2.00} = 261 \text{ k}$

(c) Bearing strength of bolts

$$L_c = \text{lesser of } 2 - (\frac{1}{2})(\frac{7}{8} + \frac{1}{8}) = 1.50 \text{ in. or } 3 - (\frac{7}{8} + \frac{1}{8}) = 2.00 \text{ in.}$$

$$R_m = 1.2 L_c \phi F_u (\text{No. of bolts}) \leq 2.4 d \phi F_u (\text{No. of bolts})$$

$$R_m = (1.2)(1.50)(1.0)(58)(9) = 939.6 \text{ k} < (2.4)(\frac{7}{8})(1.0)(58)(9) = 1096.2 \text{ k}$$

LRFD $\phi = 0.75$	ASD $\Omega = 2.00$
$\phi R_m = (0.75)(939.6) = 704.7 \text{ k}$	$\frac{R_m}{\Omega} = \frac{939.6}{2.00} = 469.8 \text{ k}$

(d) Double shearing strength of bolts

$$R_m = F_u A_b (\text{No. of bolts}) = (48)(2 \times 0.60)(9) = 518.4 \text{ k}$$

LRFD $\phi = 0.75$	ASD $\Omega = 2.00$
$\phi R_m = (0.75)(518.4) = 388.8 \text{ k}$	$\frac{R_m}{\Omega} = \frac{518.4}{2.00} = 259.2 \text{ k}$

ANSWERS.

388.8 k LRFD

258.7 k ASD

✓ JCMC

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EXCLUSIVE: Just in Edutruth only

PROB# 12-8

SKETCH SAME AS FOR PROB# 12-6

(a) Gross section yielding of plates

$$P_m = F_y A_g = (36)(1 \times 12) = 432 \text{ k}$$

LRFD $\phi_t = 0.90$	ASD $\Omega_t = 1.67$
$\phi_t P_m = (0.90)(432) = 388.8 \text{ k}$	$\frac{P_m}{\Omega_t} = \frac{432}{1.67} = 258.7 \text{ k}$

(b) Tensile rupture of plates

$$A_n = (1 \times 12) - (2)\left(\frac{3}{4} + \frac{1}{8}\right)(1.0) = 9.375 \text{ in.}^2$$

$u = 1.0$ as all plates connected

$$P_m = F_u A_e = (58)(9.375 \times 1.0) = 543.75 \text{ k}$$

LRFD $\phi_t = 0.75$	ASD $\Omega_t = 2.00$
$\phi_t P_m = (0.75)(543.75) = 407.8 \text{ k}$	$\frac{P_m}{\Omega_t} = \frac{543.75}{2.00} = 271.9 \text{ k}$

(c) Bearing strength of bolts

$$L_c = \text{lesser of } 2 - \left(\frac{1}{2}\right)\left(\frac{3}{4} + \frac{1}{8}\right) = 1.5625 \text{ or } 3 - \left(\frac{3}{4} + \frac{1}{8}\right) = 2.125 \text{ in.}$$

$$R_m = 1.2 L_c \leq F_u (\text{No of bolts}) \leq 2.4 d \leq F_u (\text{No of bolts})$$

$$R_m = (1.2)(1.5625)(1.0)(58)(4) = 978.75 \text{ k} > (2.4)\left(\frac{3}{4}\right)(1.0)(58)(4) = 939.6 \text{ k}$$

LRFD $\phi = 0.75$	ASD $\Omega = 2.00$
$\phi R_m = (0.75)(939.6) = 704.7 \text{ k}$	$\frac{R_m}{\Omega} = \frac{939.6}{2.00} = 469.8 \text{ k}$

(d) Double shearing strength of bolts

$$R_m = F_u A_b (\text{No of bolts}) = (48)(2 \times 0.44)(4) = 380.16 \text{ k}$$

LRFD $\phi = 0.75$	ASD $\Omega = 2.00$
$\phi R_m = (0.75)(380.16) = 285.1 \text{ k}$	$\frac{R_m}{\Omega} = \frac{380.16}{2.00} = 190.1 \text{ k}$

ANSWERS.

285.1 k LRFD

190.1 k ASD

VGC MC

EXCLUSIVE: Just in Edutruth only

PROB# 12-9

SKETCH SAME AS FOR PROB# 12-6

(a) Gross section yielding of plates

$$P_m = F_y A_g = (50)(1 \times 12) = 600 \text{ k}$$

LRFD $\phi_t = 0.90$	ASD $\Omega_t = 1.67$
$\phi_t P_m = (0.90)(600) = 540 \text{ k}$	$\frac{P_m}{\Omega_t} = \frac{600}{1.67} = 359.3 \text{ k}$

(b) Tensile rupture of plates

$$A_m = (1 \times 12) - (3) \left(\frac{7}{8} + \frac{1}{8} \right) (10) = 9.00 \text{ in.}^2$$

$U = 1.0$ as all plates connected

$$P_m = F_u A_e = (70)(9.00 \times 1.0) = 630 \text{ k}$$

LRFD $\phi_t = 0.75$	ASD $\Omega_t = 2.00$
$\phi_t P_m = (0.75)(630) = 472.5 \text{ k}$	$\frac{P_m}{\Omega_t} = \frac{630}{2.00} = 315 \text{ k}$

(c) Bearing strength of bolts

$$L_e = \text{lesser of } 2 - \frac{1}{2} \left(\frac{7}{8} + \frac{1}{8} \right) = 1.50 \text{ in. or } 3 - \left(\frac{7}{8} + \frac{1}{8} \right) = 2.00 \text{ in.}$$

$$R_m = 1.3 L_e \leq F_u (\text{No of bolts}) \leq 2.4 d \leq F_u (\text{No of bolts})$$

$$R_m = (1.2)(1.50)(1.0)(70)(9) = 1134 \text{ k} < (2.4) \left(\frac{7}{8} \right) (1.0)(70)(9) = 1323 \text{ k}$$

LRFD $\phi = 0.75$	ASD $\Omega = 2.00$
$\phi R_m = (0.75)(1134) = 850.5 \text{ k}$	$\frac{R_m}{\Omega} = \frac{1134}{2.00} = 567 \text{ k}$

(d) Double shearing strength of bolts

$$R_m = F_n A_b (\text{No of bolts}) = (75)(2 \times 0.60)(9) = 810 \text{ k}$$

LRFD $\phi = 0.75$	ASD $\Omega = 2.00$
$\phi R_m = (0.75)(810) = 607.5 \text{ k}$	$\frac{R_m}{\Omega} = \frac{810}{2.00} = 405 \text{ k}$

ANSWRS.

472.5k LRFD

315k ASD

296

✓ JCMC

EXCLUSIVE: Just in Edutruth only

PROB # 12-10

SKETCH SAME AS FOR PROB#12-6

(a) Gross section yielding of plates

$$P_m = F_y A_g = (50)(1 \times 12) = 600 \text{ k}$$

LRFD $\phi_t = 0.90$	ASD $\Omega_t = 1.67$
$\phi_t P_m = (0.90)(600) = 540 \text{ k}$	$\frac{P_m}{\Omega_t} = \frac{600}{1.67} = 359.3 \text{ k}$

(b) Tensile rupture of plates

$$A_n = (1 \times 12) - (3 \times (1 + \frac{1}{8})) (1.0) = 8.625 \text{ in.}^2$$

$u = 1.0$ as all parts connected

$$P_m = F_u A_n = (70)(8.625) = 603.75 \text{ k}$$

→

LRFD $\phi_t = 0.75$	ASD $\Omega_t = 2.00$
$\phi_t P_m = (0.75)(603.75) = 452.8 \text{ k}$	$\frac{P_m}{\Omega_t} = \frac{603.75}{2.00} = 301.9 \text{ k}$

(c) Bearing strength of bolts

$$L_c = \text{lesser of } 2 - \frac{1}{2}(1 + \frac{1}{8}) = 1.4375 \text{ in. or } 3 - (1 + \frac{1}{8}) = 1.875 \text{ in.}$$

$$R_m = 1.2 L_c \leq F_u (\text{No of bolts}) \leq 2.4 d \leq F_u (\text{No of bolts})$$

$$R_m = (1.2)(1.4375)(1.0)(70)(9) = 1086.7 \text{ k} < (2.4)(1.0)(1.0)(70)(9) = 1512 \text{ k}$$

LRFD $\phi = 0.75$	ASD $\Omega = 2.00$
$\phi R_m = (0.75)(1086.7) = 815 \text{ k}$	$\frac{R_m}{\Omega} = \frac{1086.7}{2.00} = 543.3 \text{ k}$

(d) Double shearing strength of the bolts

$$R_m = F_n A_b (\text{No of bolts}) = (75)(2 \times 0.785)(9) = 1059.75 \text{ k}$$

LRFD $\phi = 0.75$	ASD $\Omega = 2.00$
$\phi R_m = (0.75)(1059.75) = 794.8 \text{ k}$	$\frac{R_m}{\Omega} = \frac{1059.75}{2.00} = 529.9 \text{ k}$

ANSWERS

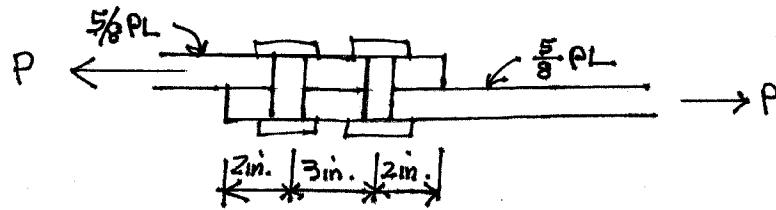
452.8 k LRFD

301.9 k ASD

✓ gcm

EXCLUSIVE: Just in Edutruth only

PROB# 12-11



LRFD	ASD
$P_u = (1.2)(50) + (1.6)(100) = 220 \text{ k}$	$P_a = 50 + 100 = 150 \text{ k}$

Bolts in SS & Bearing on $\frac{5}{8}$ in.

Bearing strength of 1 bolt

$$L_c = \text{lesser of } 2 - \left(\frac{1}{2}\right)\left(\frac{7}{8} + \frac{1}{8}\right) = \underline{1.5 \text{ in.}} \text{ or } 3 - \left(\frac{7}{8} + \frac{1}{8}\right) = 2.00 \text{ in.}$$

$$R_m = 1.2 L_c \leq F_u \leq 2.4 d \leq F_u$$

$$R_m = (1.2)(1.5)\left(\frac{5}{8}\right)(58) = \underline{65.25 \text{ k}} < (2.4)\left(\frac{7}{8}\right)\left(\frac{5}{8}\right)(58) = 76.12 \text{ k}$$

Shearing strength of 1 bolt

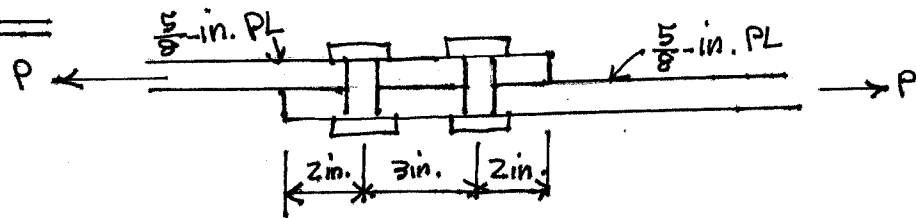
$$R_m = (0.6)(60) = 36 \text{ k} \leftarrow$$

LRFD $\phi = 0.75$	ASD $\Omega = 2.00$
$\phi R_m = (0.75)(36) = 27 \text{ k}$	$\frac{R_m}{\Omega} = \frac{36}{2.00} = 18.00 \text{ k}$
No of bolts reqd = $\frac{P_u}{\phi R_m}$	No of bolts reqd = $\frac{P_a}{\frac{R_m}{\Omega}}$
$= \frac{220}{27} = 8.15$	$= \frac{150}{18} = 8.33$
USE 9- $\frac{7}{8}$ bearing type A325 bolts	USE 9- $\frac{7}{8}$ bearing type A325 bolts

✓ gcm

EXCLUSIVE: Just in Edutruth only

PROB# 12-12



LRFD	ASD
$P_u = (1.2 \times 50) + (1.6 \times 100) = 220 \text{ k}$	$P_a = 50 + 100 = 150 \text{ k}$

Bolts in SS & Bearing on $\frac{5}{8}$ in.

Bearing strength of 1 bolt

$$L_c = \text{lesser of } 2 - \frac{1}{2} \left(\frac{3}{4} + \frac{1}{8} \right) = \underline{1.5625 \text{ in.}} \text{ or } 3 - \left(\frac{3}{4} + \frac{1}{8} \right) = 2.125 \text{ in.}$$

$$R_m = 1.2 L_c t F_u \leq 2.4 d t F_u$$

$$R_m = (1.2)(1.5625) \left(\frac{5}{8} \right) (70) = 82.03 \text{ k} > (2.4) \left(\frac{3}{4} \right) \left(\frac{5}{8} \right) (70) = \underline{78.75 \text{ k}}$$

Shearing strength of 1 bolt

$$R_m = (0.44)(60) = 26.4 \text{ k} \leftarrow$$

LRFD $\phi = 0.75$	ADD $\Omega = 2.00$
$\phi R_m = (0.75)(26.4) = 19.8 \text{ k}$	$\frac{R_m}{\Omega} = \frac{26.4}{2.00} = 13.2 \text{ k}$
No of bolts reqd = $\frac{220}{19.8}$	No of bolts reqd = $\frac{150}{13.2}$
= 11.11	= 11.36

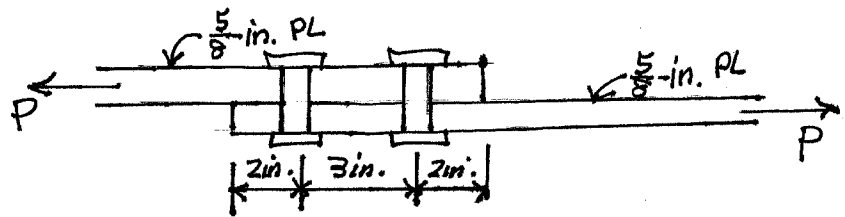
USE 12 - $\frac{3}{4}$ bolts
bearing type A325

USE 12 - $\frac{3}{4}$ in. bearing
type A325 bolts

✓ JCM

EXCLUSIVE: Just in Edutruth only

PROB # 12-13



LRFD	ASD
$P_u = (1.2)(50) + (1.6)(100) = 220 \text{ k}$	$P_a = 50 + 100 = 150 \text{ k}$

Bolts in SS & Bearing on $\frac{5}{8}$ in.

Bearing strength of 1 bolt

$$L_c = \text{lesser of } 2 - \frac{1}{2} \left(\frac{7}{8} + \frac{1}{8} \right) = 1.50 \text{ in. or } 3 - \left(\frac{7}{8} + \frac{1}{8} \right) = 2.00 \text{ in.}$$

$$R_m = 1.2 L_c \leq F_u \leq 2.4 d \leq F_u$$

$$R_m = (1.2)(1.50) \left(\frac{5}{8} \right) (58) = 65.25 \text{ k} < (2.4) \left(\frac{7}{8} \right) \left(\frac{5}{8} \right) (58) = 76.12 \text{ k}$$

Shearing strength of 1 bolt

$$R_m = (0.6)(48) = 28.8 \text{ k} \leftarrow$$

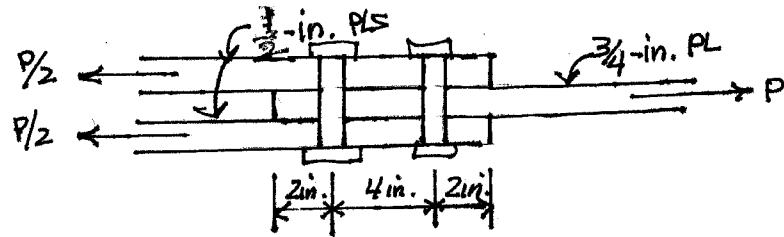
LRFD $\phi = 0.75$	ASD $\Omega = 2.00$
$\phi R_m = (0.75)(28.8) = 21.6 \text{ k}$	$\frac{R_m}{\Omega} = \frac{28.8}{2.00} = 14.4 \text{ k}$
No. of bolts reqd = $\frac{220}{21.6}$	No. of bolts reqd = $\frac{150}{14.4}$
= 10.19	= 10.42
USE 11 or 12 - $\frac{7}{8}$ -in. A325 bearing bolts	USE 11 or 12 - $\frac{7}{8}$ -in. A325 bearing bolts

✓ JCM

300

EXCLUSIVE: Just in Edutruth only

PROB# 12-14



LRFD	ASD
$P_u = (1.2)(120) + (1.6)(150) = 384 \text{ k}$	$P_a = 120 + 150 = 270 \text{ k}$

Bolts in DS & Bearing on $\frac{3}{4}$ in.

Bearing strength of 1 bolt

$$L_c = \text{lesser of } 2 - \frac{1}{2} \left(\frac{7}{8} + \frac{1}{8} \right) = 1.50 \text{ in. or } 4 - \left(\frac{7}{8} + \frac{1}{8} \right) = 3.0 \text{ in.}$$

$$R_m = 1.2 L_c \leq F_u \leq 2.4 d \leq F_u$$

$$R_m = (1.2)(1.50) \left(\frac{3}{4} \right) (58) = 78.3 \text{ k} < (2.4) \left(\frac{7}{8} \right) \left(\frac{3}{4} \right) (58) = 91.35 \text{ k}$$

Double Shearing strength of 1 bolt

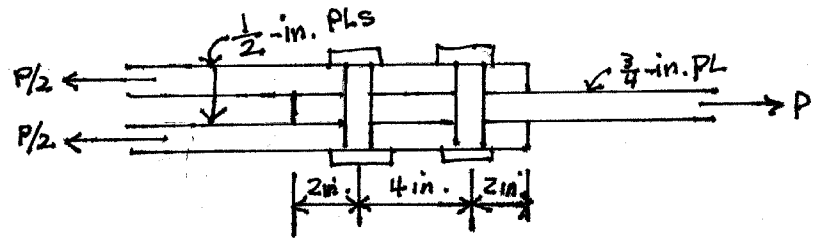
$$R_m = (2)(0.60)(60) = 72 \text{ k} \leftarrow$$

LRFD $\phi = 0.75$	ASD $\Omega = 2.00$
$\phi R_m = (0.75)(72) = 54 \text{ k}$ No of bolts reqd = $\frac{384}{54} = 7.11$	$\frac{R_m}{\Omega} = \frac{72}{2.00} = 36 \text{ k}$ No of bolts reqd = $\frac{270}{36} = 7.50$
USE 8- $\frac{7}{8}$ -in. A325 bearing bolts	USE 8- $\frac{7}{8}$ -in. A325 bearing bolts

✓ JCMC

EXCLUSIVE: Just in Edutruth only

PROB #12-15



LRFD	ASD
$P_u = (1.2)(120) + (1.6)(150) = 384 \text{ k}$	$P_a = 120 + 150 = 270 \text{ k}$

Bolts in DS & Bearing on $\frac{3}{4}$ in.

Bearing strength of 1 bolt
 $L_c = \text{lesser of } 2 - \frac{1}{2} \left(\frac{3}{4} + \frac{1}{8} \right) = 1.5625 \text{ in. or } 4 - \left(\frac{3}{4} + \frac{1}{8} \right) = 3.125 \text{ in.}$

$$R_m = 1.2 L_c t F_u \leq 2.4 d t F_u$$

$$R_m = (1.2)(1.5625) \left(\frac{3}{4} \right) (58) = 81.56 \text{ k} > (2.4) \left(\frac{3}{4} \right) \left(\frac{3}{4} \right) (58) = 78.3 \text{ k}$$

Double shearing strength of 1 bolt

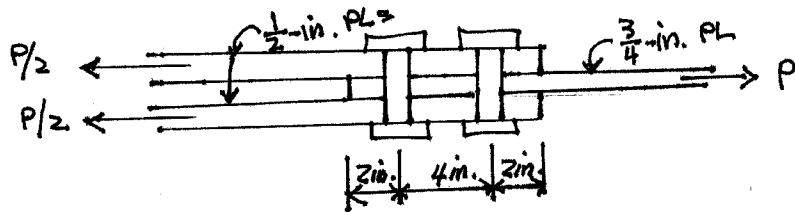
$$R_m = (2)(0.44)(48) = 42.24 \text{ k} \leftarrow$$

LRFD $\phi = 0.75$	ASD $\Omega = 2.00$
$\phi R_m = (0.75)(42.24) = 31.68 \text{ k}$ No of bolts reqd = $\frac{384}{31.68} = 12.12$	$\frac{R_m}{\Omega} = \frac{42.24}{2.00} = 21.12 \text{ k}$ No of bolts reqd = $\frac{270}{21.12} = 12.78$
<div style="border: 1px solid black; padding: 5px; width: fit-content;"> USE 13 or 14 - $\frac{3}{4}$ bolts (A325) bearing type conn. </div>	<div style="border: 1px solid black; padding: 5px; width: fit-content;"> USE 13 or 14 - $\frac{3}{4}$ A325 bearing bolts </div>

✓ JCM

EXCLUSIVE: Just in Edutruth only

PROB # 12-16



LRFD	ASD
$P_u = (1.2)(120) + (1.6)(150) = 384 \text{ k}$	$P_a = 120 + 150 = 270 \text{ k}$

Bolts in DS & Bearing on $\frac{3}{4}$ in.

Bearing strength of 1 bolt

$$L_c = \text{lesser of } 2 \rightarrow \frac{1}{2} \left(1\frac{1}{8} + \frac{1}{8} \right) = 1.375 \text{ in. or } 4 \rightarrow \left(1\frac{1}{8} + \frac{1}{8} \right) = 2.75 \text{ in.}$$

$$R_m = 1.2 L_c \leq F_u \leq 2.4 d \leq F_u$$

$$\rightarrow R_m = (1.2)(1.375) \left(\frac{3}{4} \right) (58) = 71.77 \text{ k} < (2.4) \left(1\frac{1}{8} \right) \left(\frac{3}{4} \right) (58) = 117.4 \text{ k}$$

Double Shear Strength of 1 Bolt

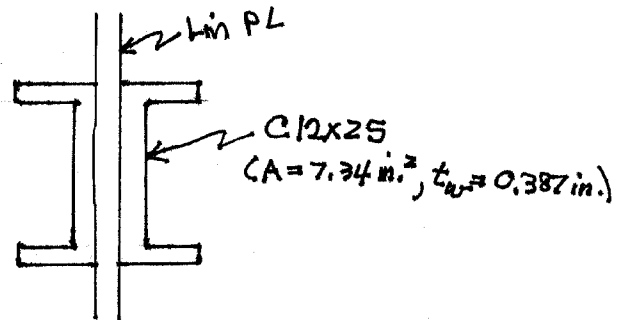
$$R_m = (2)(0.994)(60) = 119.3 \text{ k}$$

LRFD $\phi = 0.75$	ASD $\Omega = 2.00$
$\phi R_m = (0.75)(71.77) = 53.83 \text{ k}$	$\frac{R_m}{\Omega} = \frac{71.77}{2.00} = 35.88 \text{ k}$
No of bolts reqd = $\frac{384}{53.83}$	No of bolts reqd = $\frac{270}{35.88}$
= 7.13	= 7.53
USE 8- $\frac{1}{8}$ -in. A325 bearing bolts	USE 8- $\frac{1}{8}$ -in. A325 bearing bolts

✓ JCM

EXCLUSIVE: Just in Edutruth only

PROB# 12-17



Bolts in DS and Bearing on $2 \times 0.387 = 0.774$ in.

(a) Gross section yielding of channels

$$P_m = F_y A_g = (36)(2 \times 7.34) = 528.5 \text{ k}$$

LRFD $\phi_t = 0.90$	ASD $\Omega_t = 1.67$
$\phi_t P_m = (0.90)(528.5) = 475.6 \text{ k}$	$\frac{P_m}{\Omega_t} = \frac{528.5}{1.67} = 316.5 \text{ k}$

(b) Tensile rupture strength of channels

$$A_n = (2)(7.34) - (4)(0.387)\left(\frac{7}{8} + \frac{1}{8}\right) = 13.13 \text{ in.}^2$$

$$u_{\text{given}} = 0.85$$

$$P_m = F_u A_e = F_u u A_n = (58)(0.85)(13.13) = 647.3 \text{ k}$$

LRFD $\phi_t = 0.75$	ASD $\Omega_t = 2.00$
$\phi_t P_m = (0.75)(647.3) = 485.5 \text{ k}$	$\frac{P_m}{\Omega_t} = \frac{647.3}{2.00} = 323.6 \text{ k}$

304

EXCLUSIVE: Just in Edutruth only

PROB #12-17 CONTD.

(c) Bearing strength of 1 bolt

$$L_c = 2 - \left(\frac{1}{2}\right)\left(\frac{7}{8} + \frac{1}{8}\right) = 1.50 \text{ in.}$$

$$R_m = 1.2 L_c \leq F_u \leq 2.4 d \leq F_u$$

$$R_m = (1.2)(1.5)(0.774)(58) = \underline{80.8 \text{ k}} < (2.4)\left(\frac{7}{8}\right)(0.774)(58) = 94.3 \text{ k}$$

LRFD $\phi = 0.75$	ASD $\Omega = 2.00$
$\phi R_m = (0.75)(80.8) = 60.6 \text{ k}$	$\frac{R_m}{\Omega} = \frac{80.8}{2.00} = 40.4 \text{ k}$

(d) Double shearing strength of 1 bolt

$$R_m = F_m A_b = (60)(2 \times 0.6) = 72 \text{ k}$$

LRFD $\phi = 0.75$	ASD $\Omega = 2.00$
$\phi R_m = (0.75)(72) = 54 \text{ k}$	$\frac{R_m}{\Omega} = \frac{72}{2.00} = 36 \text{ k}$

<p>No. of bolts reqd. LRFD</p> $= \frac{475.6}{54} = 8.81$ <p>USE 9 BOLTS</p>

<p>No. of bolts reqd. ASD</p> $= \frac{316.5}{36} = 8.79$ <p>USE 9 BOLTS</p>
--

✓ JCMC

EXCLUSIVE: Just in Edutruth only

PROB # 12-18

Sketch same as the one used for the solution of PROB # 12-17,

Bolts in DS and bearing on $2 \times 0.387 = 0.774$ in.

(a) Gross section yielding of channels

$$P_m = F_y A_g = (50)(2 \times 7.34) = 734 \text{ k}$$

LRFD $\phi_t = 0.90$	ASD $\Omega_t = 1.67$
$\phi_t P_m = (0.90)(734) = 660.6 \text{ k}$	$\frac{P_m}{\Omega_t} = \frac{734}{1.67} = 439.5 \text{ k}$

(b) Tensile rupture strength of channels

$$A_m = (2)(7.34) - (4)(0.387)\left(\frac{7}{8} + \frac{1}{8}\right) = 13.13 \text{ in.}^2$$

$$u_{\text{given}} = 0.85$$

$$P_m = F_u A_e = F_u u A_m = (70)(0.85)(13.13) = 781.2 \text{ k}$$

LRFD $\phi_t = 0.75$	ASD $\Omega_t = 2.00$
$\phi_t P_m = (0.75)(781.2) = 585.9 \text{ k}$	$\frac{P_m}{\Omega_t} = \frac{781.2}{2.00} = 390.6 \text{ k} \leftarrow$

EXCLUSIVE: Just in Edutruth only

PROB # 12-18 CONTD.

(c) Bearing strength of 1 bolt

$$L_c = 2 - \left(\frac{1}{2}\right)\left(\frac{7}{8} + \frac{1}{8}\right) = 1.50 \text{ in.}$$

$$R_m = 1.2 L_c t F_u \leq 2.4 d t F_u$$

$$R_m = (1.2)(1.5)(0.774)(70) = \underline{97.5 \text{ k}} < (2.4)\left(\frac{7}{8}\right)(0.774)(70) = 113.8 \text{ k}$$

LRFD $\phi = 0.75$	ASD $\Omega = 2.00$
$\phi R_m = (0.75)(113.8) = 85.3 \text{ k}$	$\frac{R_m}{\Omega} = \frac{113.8}{2.00} = 56.9 \text{ k}$

(d) Double shearing strength of bolts

$$R_m = F_u A_b = (75)(2 \times 0.6) = 90 \text{ k}$$

LRFD $\phi = 0.75$	ASD $\Omega = 2.00$
$\phi R_m = (0.75)(90) = 67.5 \text{ k}$ No of bolts reqd. $= \frac{585}{67.5} = 8.68$ <div style="border: 1px solid black; padding: 2px; display: inline-block;">USE 9 BOLTS</div>	$\frac{R_m}{\Omega} = \frac{90}{2.00} = 45 \text{ k}$ No of bolts reqd. $= \frac{390.6}{45} = 8.68$ <div style="border: 1px solid black; padding: 2px; display: inline-block;">USE 9 BOLTS</div>

✓ gcm

EXCLUSIVE: Just in Edutruth only

PROB# 12-19

Sketch same as the one
used for the solution
of PROB# 12-17.

Bolts in D.S. and bearing on $2 \times 0.387 = 0.774$ in.

(a) Gross section yielding of channels

$$P_m = F_y A_g = (50)(2 \times 7.34) = 734 \text{ k}$$

LRFD $\phi_t = 0.90$	ASD $\Omega_t = 1.67$
$\phi_t P_m = (0.90)(734) = 660.6 \text{ k}$	$\frac{P_m}{\Omega_t} = \frac{734}{1.67} = 439.5 \text{ k}$

(b) Tensile rupture strength of channels

$$A_m = (2)(7.34) - (4)(0.387)\left(1 + \frac{1}{8}\right) = 12.94 \text{ in.}^2$$

$$u \text{ given} = 0.85$$

$$P_m = F_u A_e = F_u u A_m = (65)(0.85)(12.94) = 714.9 \text{ k}$$

LRFD $\phi_t = 0.75$	ASD $\Omega_t = 2.00$
$\phi_t P_m = (0.75)(714.9) = 536.2 \text{ k}$	$\frac{P_m}{\Omega_t} = \frac{714.9}{2.00} = 357.4 \text{ k}$

EXCLUSIVE: Just in Edutruth only

PROB # 12-19 CONTD.

(c) Bearing strength of 1 bolt

$$L_c = 2 - \left(\frac{1}{2}\right)\left(1 + \frac{1}{8}\right) = 1.44 \text{ in.}$$

$$R_n = 1.2 L_c t F_u \leq 2.4 d t F_u$$

$$R_n = (1.2)(1.44)(0.774)(65) = \underline{86.9 \text{ k}} < (2.4)(1.0)(0.774)(65) = 120 \text{ k}$$

LRFD $\phi = 0.75$	ASD $\Omega = 2.00$
$\phi R_n = (0.75)(86.9) = 65.2 \text{ k}$	$\frac{R_n}{\Omega} = \frac{86.9}{2.00} = 43.4 \text{ k}$

(d) Double shearing strength of 1 bolt

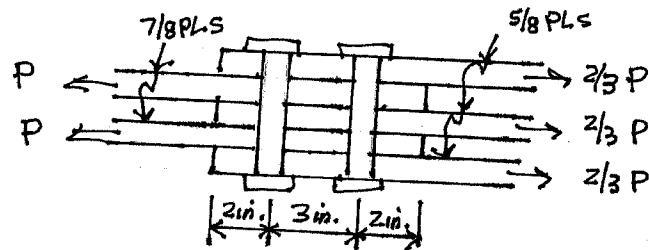
$$R_n = F_u A_b = (75)(2 \times 0.785) = 117.7 \text{ k}$$

LRFD $\phi = 0.75$	ASD $\Omega = 2.00$
$\phi R_n = (0.75)(117.7) = 88.3 \text{ k}$ No of bolts reqd $= \frac{536.2}{65.2} = 8.22$ <div style="border: 1px solid black; padding: 2px; display: inline-block;">USE 9 BOLTS</div>	$\frac{R_n}{\Omega} = \frac{117.7}{2.00} = 58.8 \text{ k}$ No of bolts reqd $= \frac{357.4}{43.4} = 8.24$ <div style="border: 1px solid black; padding: 2px; display: inline-block;">USE 9 BOLTS</div>

✓ JCM

EXCLUSIVE: Just in Edutruth only

PROB #12-20



LRFD	ASD
$P_u = 360 \text{ k}$	$P_a = 260 \text{ k}$

Bolts in multiple shear but assume they are in
DS and bearing on $2 \times \frac{7}{8} = 1.75 \text{ in.}$

Bearing strength of 1 bolt

$$L_c = \text{lesser of } 2 - \left(\frac{1}{2}\right)\left(1 + \frac{1}{8}\right) = 1.4375 \text{ in. or } 3 - \left(1 + \frac{1}{8}\right) = 1.875 \text{ in.}$$

$$R_n = 1.2 L_c t F_u \leq 2.4 d t F_u$$

$$R_n = (1.2)(1.4375)(1.75)(58) = 175.1 \text{ k} < (2.4)(1)(1.75)(58) = 243.6 \text{ k}$$

Double shear strength of 1 bolt

$$R_n = (2)(0.785)(60) = 94.2 \text{ k} \leftarrow$$

LRFD $\phi = 0.75$	ASD $\Omega = 2.00$
$\phi R_n = (0.75)(94.2) = 70.65 \text{ k}$ No of bolts reqd $= \frac{(2)(360)}{70.6} = 10.19$ <div style="border: 1px solid black; padding: 5px; width: fit-content;">USE 11 OR 12 1-in A325 BEARING BOLTS</div>	$\frac{R_n}{\Omega} = \frac{94.2}{2.00} = 47.1 \text{ k}$ No. of bolts reqd $= \frac{(2)(260)}{47.1} = 11.05$ <div style="border: 1px solid black; padding: 5px; width: fit-content;">USE 12 1-in. A325 BEARING BOLTS</div>

✓ gcm

310

EXCLUSIVE: Just in Edutruth only

PROB #12-21

Sketch same as shown for the solution of Prob. #12-20

LRFD	ASD
$P_u = 360k$	$P_a = 260k$

Bolts actually in multiple shear but assume they are in double shear & bearing on $2 \times \frac{7}{8} = 1\frac{3}{4}$ in.

Bearing strength of 1 bolt

$$L_c = \text{lesser of } 2 - \left(\frac{1}{2}\right)\left(\frac{7}{8} + \frac{1}{8}\right) = 1.50 \text{ in. or } 3 - \left(\frac{7}{8} + \frac{1}{8}\right) = 2.0 \text{ in.}$$

$$R_m = 1.2 L_c t F_u \leq 2.4 d t F_u$$

$$R_m = (1.2)(1.5)(1.75)(58) = 182.7k < (2.4)\left(\frac{7}{8}\right)(1.75)(58) = 213k$$

Double shear strength of 1 bolt

$$DS = (2)(0.6)(60) = 72k \leftarrow$$

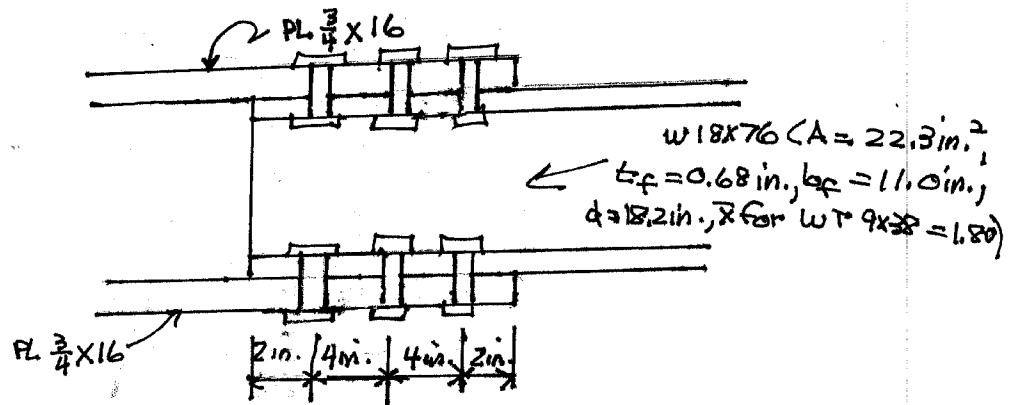
LRFD $\phi = 0.75$	ASD $\Omega = 2.00$
$\phi R_m = (0.75)(72) = 54k$ No. of bolts reqd $= \frac{360 \times 2}{54} = 13.33$ <div style="border: 1px solid black; padding: 5px; display: inline-block;">USE 14 $\frac{7}{8}$ A490 BOLTS</div>	$\frac{R_m}{\Omega} = \frac{72}{2.00} = 36.00k$ No. of bolts reqd $= \frac{260 \times 2}{36}$ $= 14.44$ <div style="border: 1px solid black; padding: 5px; display: inline-block;">USE 15 - $\frac{7}{8}$ A490 Bolts</div>

✓ JCM

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EXCLUSIVE: Just in Edutruth only

PROB # 12-22



(a) Tensile yielding of connecting elements

$$P_n = (36)(2)(\frac{3}{4} \times 16) = 864 \text{ k}$$

LRFD $\phi_t = 0.90$	ASD $\Omega_t = 1.67$
$\phi P_n = (0.9)(864) = 777.6 \text{ k}$	$\frac{P_n}{\Omega_t} = \frac{864}{1.67} = 517.4 \text{ k}$

(b) Tensile rupture of connecting elements

$$A_n \text{ of plates} = (2) \left[\frac{3}{4} \times 16 - \left(\frac{3}{4} + \frac{1}{8} \right) \left(\frac{3}{4} \times 2 \right) \right] = 21.375 \text{ in.}^2$$

or

$$0.85 A_g = (0.85)(2 \times \frac{3}{4} \times 16) = 20.4 \text{ in.}^2$$

$U = 1.0$

$$P_n = F_u A_e = (58)(1.0)(20.4) = 1183.2 \text{ k}$$

LRFD $\phi_t = 0.75$	ASD $\Omega_t = 2.00$
$\phi P_n = (0.75)(1183.2) = 887.4 \text{ k}$	$\frac{P_n}{\Omega_t} = \frac{1183.2}{2.00} = 591.6 \text{ k}$

(c) Tensile yielding of W section

$$P_n = (36)(22.3) = 802.8 \text{ k}$$

LRFD $\phi_t = 0.9$	ASD $\Omega_t = 1.67$
$\phi P_n = (0.9)(802.8) = 722.5 \text{ k}$	$\frac{P_n}{\Omega_t} = \frac{802.8}{1.67} = 480.7 \text{ k}$

EXCLUSIVE: Just in Edutruth only

PROB# 12-22 CONTD.

(d) Tensile rupture strength of W section

$$A_m = 22.3 - (4) \left(\frac{3}{4} + \frac{1}{8} (0.68) \right) = 19.92 \text{ in.}^2$$

$$\bar{x} = \bar{y} = 1.80 \text{ in for WT9x38}$$

$$u = 1 - \frac{\bar{x}}{L} = 1 - \frac{1.80}{2 \times 4} = 0.775$$

$$b_f = 11 < \frac{2}{3} d = \frac{2}{3} \times 18.2 = 12.13 \text{ in.}$$

$$\therefore u = 0.85 \text{ (Case 7 AISI Table D3.1)}$$

$$P_m = F_u A_e = (58)(0.85 \times 19.92) = 982 \text{ k}$$

LRFD $\phi_t = 0.75$	ASD $\Omega_t = 2.00$
$\phi_t P_m = (0.75)(982) = 736.5 \text{ k}$	$\frac{P_m}{\Omega_t} = \frac{982}{2.00} = 491 \text{ k}$

(e) Bolts in SS and Bearing on 0.68 in.

SS Strength of 1 bolt

$$R_m = F_m A_b = (60)(0.44) = 26.4 \text{ k}$$

LRFD $\phi = 0.75$	ASD $\Omega = 2.00$
$\phi R_m = (0.75)(26.4) = 19.8 \text{ k}$	$\frac{R_m}{\Omega} = \frac{26.4}{2.00} = 13.2 \text{ k}$

Bearing strength of 1 bolt

$$L_c = 2 - \frac{1}{2} \left(\frac{3}{4} + \frac{1}{8} \right) = 1.56 \text{ in.}$$

$$R_m = 1.2 L_c \leq F_u \leq 2.4 d \leq F_u$$

$$R_m = (1.2)(1.56)(0.68)(58) = 73.83 \text{ k} < (2.4) \left(\frac{3}{4} \right) (0.68)(58) = 70.99 \text{ k}$$

LRFD $\phi = 0.75$	ASD $\Omega = 2.00$
$\phi R_m = (0.75)(70.99) = 53.2 \text{ k}$	$\frac{R_m}{\Omega} = \frac{70.99}{2.00} = 35.5 \text{ k}$
No of bolts reqd $= \frac{722.5}{19.8} = 36.49$	No of bolts reqd $= \frac{480.7}{13.2} = 36.41$

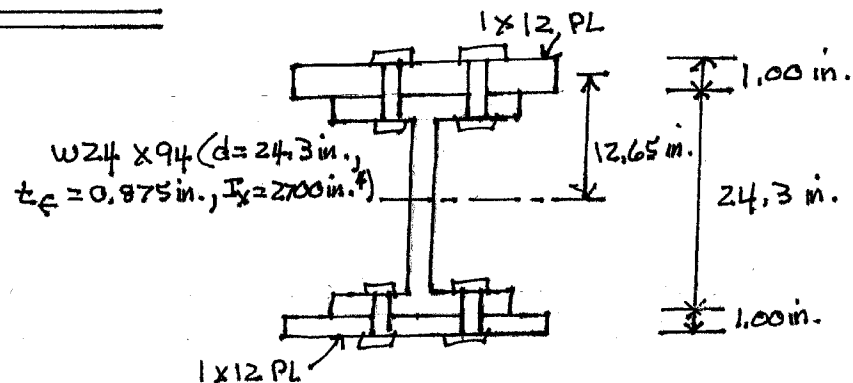
ANSWER

USE 38 to 40 bolts for both
LRFD and ASD

✓ JCM

EXCLUSIVE: Just in Edutruth only

PROB #12-23



$$Q = (1 \times 12)(12.65) = 151.8 \text{ in.}^3$$

$$I_x = 2700 + (2)(1 \times 12)(12.65)^2 = 6540.5 \text{ in.}^4$$

LRFD	ASD
$V_u = (1.2 \times 80) + (1.6 \times 160) = 352 \text{ k}$ $F_v/\text{in.} = \frac{V_u Q}{I_x} = \frac{(352)(151.8)}{6540.5}$ $= 8.17 \text{ k/ft}$	$V_a = 80 + 160 = 240 \text{ k}$ $F_v/\text{in.} = \frac{V_a Q}{I_x} = \frac{(240)(151.8)}{6540.5}$ $= 5.57 \text{ k/in.}$

Bolts in SS and bearing on 0.875 in.

Bearing strength of 1 bolt

$$L_c = 1.50 \text{ in.}$$

$$R_n = 1.2 L_c t F_u \leq 2.4 d t F_u$$

$$R_n = (1.2)(1.5)(0.875)(58) = 91.35 \text{ k} \quad (2.4)(\frac{3}{4})(0.875)(58) = 91.35 \text{ k}$$

Single shear strength of 1 bolt

$$R_n = F_u A_b = (60)(0.44) = 26.4 \text{ k}$$

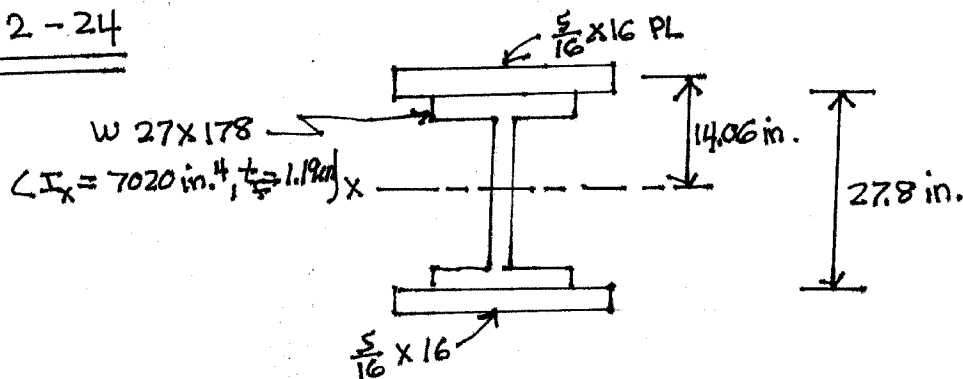
LRFD $\phi=0.75$	ASD $\Omega=2.00$
$\phi R_n = (0.75)(26.4) = 19.8 \text{ k/bolt}$ $R_{\text{reqd, bolt spacing}} = \frac{2 \times 19.8}{8.17}$ $= 4.85 \text{ in.}$ <div style="border: 1px solid black; padding: 2px; display: inline-block;">USE $4\frac{1}{2}$ in. spacing</div>	$\frac{R_n}{\Omega} = \frac{26.4}{2.00} = 13.2 \text{ k/bolt}$ $R_{\text{reqd, bolt spacing}} = \frac{2 \times 13.2}{5.57}$ $= 4.74 \text{ in.}$ <div style="border: 1px solid black; padding: 2px; display: inline-block;">USE $4\frac{1}{2}$ in. spacing</div>

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JCM

EXCLUSIVE: Just in Edutruth only

PROB #12-24



$$I_x = 7020 + (2)(\frac{5}{16} \times 16)(14.06)^2 = 8997 \text{ in.}^4$$

$$Q = (\frac{5}{16} \times 16)(14.06) = 70.3 \text{ in.}^3$$

LRFD	ASD
$w_u = (1.2)(12) + (1.6)(15) = 38.4 \text{ k/ft}$	$w_a = 12 + 15 = 27 \text{ k/ft}$
$V_u = (9)(38.4) = 345.6 \text{ k}$	$V_a = (9)(27) = 243 \text{ k}$
Shear to be taken per in. $= \frac{V_u Q}{I_x} = \frac{(345.6)(70.3)}{8997} = 2.70 \text{ k/in.}$	Shear to be taken per in. $= \frac{V_a Q}{I_x} = \frac{(243)(70.3)}{89.97} = 1.90 \text{ k/in.}$

Bolts in SS and bearing on $\frac{5}{16}$ -in.

$$\text{SS strength of 1 bolt} = R_m = (0.6)(60) = 36 \text{ k} \leftarrow$$

Bear Strength of 1 bolt

$$L_c = 2 - (\frac{1}{2})(\frac{7}{8} + \frac{1}{8}) = 1.50 \text{ in.}$$

$$R_m = 1.2 L_c \leq F_u \leq 2.4 d \leq F_u$$

$$= (1.2)(1.50)(\frac{5}{16})(58) = 32.625 \text{ k} < (2.4)(\frac{7}{8})(\frac{5}{16})(58) = 38.06 \text{ k}$$

LRFD $\phi = 0.75$	ASD $\Omega = 2.00$
$\phi R_m = (0.75)(32.625) = 24.47 \text{ k}$	$\frac{R_m}{\Omega} = \frac{32.625}{2.00} = 16.31 \text{ k}$
Spacing = $\frac{24.47}{2 \times 2.70} = 4.53 \text{ in.}$ <u>Say 4 1/2</u>	Spacing = $\frac{16.31}{2 \times 1.90} = 4.29 \text{ in.}$ <u>Say 4 in.</u>

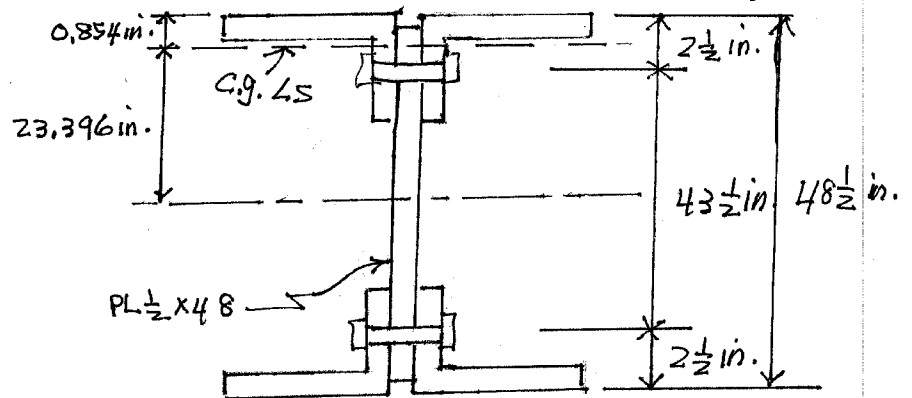
315

v g c m f

EXCLUSIVE: Just in Edutruth only

PROB # 12-25

LS 8x4x $\frac{1}{2}$ ($A=5.75 \text{ in.}^2$, $I_x=6.75 \text{ in.}^4$, $\bar{y}=0.854 \text{ in.}$)



$$Q = (2)(5.75)(23.396) = 269$$

$$I_x = \left(\frac{1}{12}\right)\left(\frac{1}{2}\right)(48)^3 + (4)(6.75) + (4)(5.75)(23.396)^2 = 17,225 \text{ in.}^4$$

LRFD	ASD
$V_u = (1.2)(100) + (1.6)(140) = 344 \text{ k}$	$V_a = 100 + 140 = 240 \text{ k}$
$\frac{V_u Q}{I} = \frac{(344)(269.05)}{17,225} = 5.373 \text{ k/in.}$	$\frac{V_a Q}{I} = \frac{(240)(269.05)}{17,225} = 3.749 \text{ k/in.}$

Bolts in DS & bearing on $\frac{1}{2}$ in.

Bearing strength of 1 bolt

$$L_c = 1.5 - \left(\frac{1}{2}\right)\left(\frac{7}{8} + \frac{1}{8}\right) = 1.00 \text{ in.}$$

$$R_m = 1.2 L_c \leq F_u \leq 2.4 d \leq F_u$$

$$R_m = (1.2)(100)\left(\frac{1}{2}\right)(75) = 45 \text{ k} < (2.4)\left(\frac{7}{8}\right)\left(\frac{1}{2}\right)(75) = 78.75 \text{ k}$$

LRFD	ASD
$\phi R_m = (0.75)(45) = 33.75 \text{ k}$	$\frac{R_m}{\Omega} = \frac{45}{2} = 22.5 \text{ k}$

Double shearing strength of 1 bolt

$$R_m = F_m A_g = (2)(75)(0.6) = 90 \text{ k}$$

LRFD $\phi=0.75$	ASD $\Omega=2.00$
$\phi R_m = (0.75)(90) = 67.5 \text{ k}$	$\frac{R_m}{\Omega} = \frac{90}{2.00} = 45 \text{ k}$

$$\text{Spacing of bolts} = \frac{33.75}{5.373} = 6.28 \text{ in.}$$

USE 6 in. LRFD

$$\text{Spacing of bolts} = \frac{22.5}{3.749} = 6.002 \text{ in.}$$

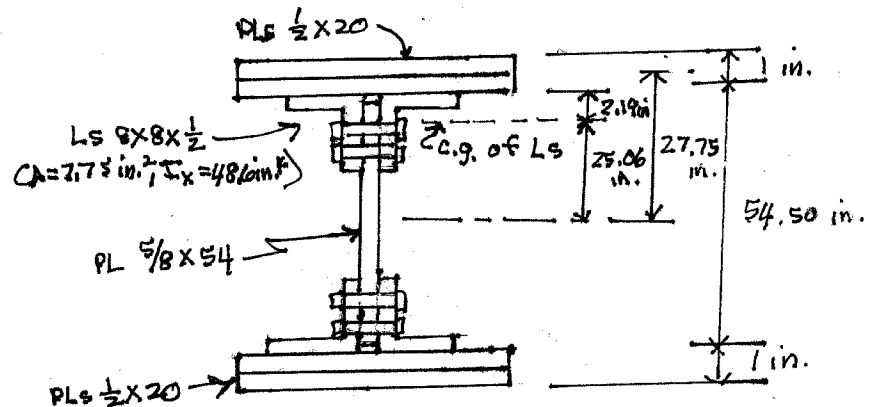
USE 6 in. ASD

316

✓ JCM

EXCLUSIVE: Just in Edutruth only

PROG#12-26



$$Q = (2)(\frac{1}{2} \times 20)(27.75) + (2)(7.75)(25.06) = 943.74$$

$$I_x = \left(\frac{1}{12}\right)\left(\frac{5}{8}\right)(54)^3 + (4)(48.6) + (4)(7.75)(25.06)^2 + (4)\left(\frac{1}{2} \times 20\right)(27.75)^2 = 58,666 \text{ in.}^4$$

Factored shear to be taken per in.

$$= \frac{(600)(943.74)}{58,666} = 9.65 \text{ k/in.}$$

Bolts in DS & Bearing on $\frac{5}{8}$ in.

DS strength of 1 bolt

$$R_m = F_m A_b = (2)(60)(0.785) = 94.2 \text{ k}$$

Bearing strength of 1 bolt

$$L_c = 1.5 \text{ in.}$$

$$R_m = 1.2 L_c t F_u \leq 2.4 d t F_u$$

$$R_m = (1.2)(1.5)\left(\frac{5}{8}\right)(58) = 65.25 \text{ k} = (2.4)(1)\left(\frac{5}{8}\right)(58) = 87 \text{ k}$$

Spacing of bolts

$$\phi_v R_m = (0.75)(65.25) = 48.94 \text{ k}$$

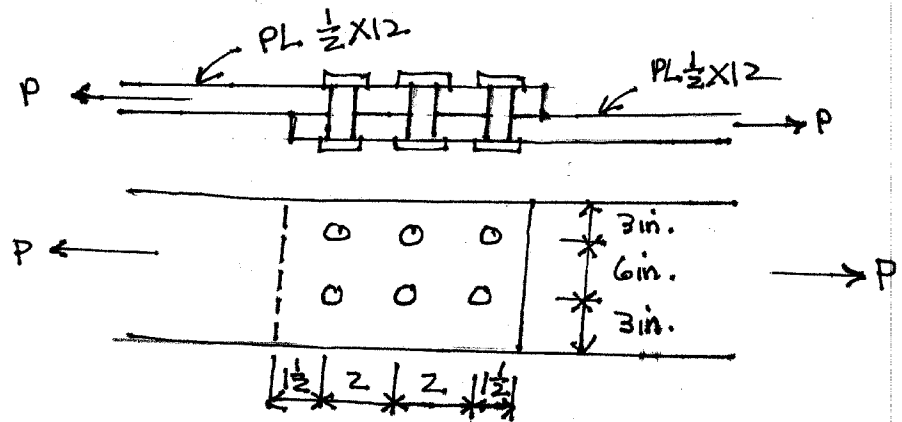
$$\text{Spacing} = \frac{48.94}{9.65} = 5.07 \text{ in.}$$

USE 5 in SPACING

✓ JCM

EXCLUSIVE: Just in Edutruth only

PROB # 12-27



(a) Gross section yielding of plates

$$P_m = F_y A_g = (36) \left(\frac{1}{2} \times 12 \right) = 216 \text{ k}$$

LRFD $\phi_t = 0.90$	ASD $\Omega_t = 1.67$
$\phi_t P_m = (0.90)(216) = 194.4 \text{ k}$	$\frac{P_m}{\Omega_t} = \frac{216}{1.67} = 129.3 \text{ k}$

(b) Tensile rupture strength of plates

$$A_n = \left(\frac{1}{2} \right) (12) - \left(2 \left(\frac{7}{8} + \frac{1}{8} \right) \right) \left(\frac{1}{2} \right) = 5.00 \text{ in.}^2$$

$u = 1.0$ as all parts connected

$$P_m = F_u A_e = F_u A_n u = (58)(5.00)(1) = 290 \text{ k}$$

LRFD $\phi_t = 0.75$	ASD $\Omega_t = 2.00$
$\phi_t P_m = (0.75)(290) = 217.5 \text{ k}$	$\frac{P_m}{\Omega_t} = \frac{290}{2.00} = 145 \text{ k}$

EXCLUSIVE: Just in Edutruth only

PROB #12-27 CONTD.

Nominal strength of 6 slip critical bolts

From AISC Section J4.9 $\mu = 0.35$ for Class A surfaces, 1.13 for multiplier, $h_{sc} = 1.00$ for standard size holes, $N_s = 1$ number of slip planes. Also from AISC Table J3.1 $T_b = 39k$.

$$R_n = 6\mu D_u h_{sc} T_b N_s = (6)(0.35)(1.13)(1.00)(39)(1) = 92.55k$$

LRFD $\phi = 1.00$	ASD $\Omega = 1.50$
$\phi R_n = (1.00)(92.55) = 92.55k$	$\frac{R_n}{\Omega} = \frac{92.55}{1.50} = 61.7k$

Bearing strength of 6 bolts

$$L_c = \text{lesser of } 1\frac{1}{2} - \frac{1}{2}\left(\frac{7}{8} + \frac{1}{8}\right) = 1.00 \text{ in. or } 2 - \left(\frac{7}{8} + \frac{1}{8}\right) = 1.00 \text{ in.}$$

$$R_n = (6 \text{ bolts})(1.5 L_c \leq F_u) \leq (6 \text{ bolts})(2.4 d \leq F_u)$$

$$R_n = (6)(1.5)(1.00)(58) = 261k < (6)(2.4)\left(\frac{7}{8}\right)\left(\frac{1}{2}\right)(58) = 365.4k$$

LRFD $\phi = 0.75$	ASD $\Omega = 2.00$
$\phi R_n = (0.75)(261) = 195.7k$	$\frac{R_n}{\Omega} = \frac{261}{2.00} = 130.5k$

Shear strength of 6 bolts

$$R_n = (6 \text{ bolts})(F_u A_b) = (6)(60)(0.6) = 216k$$

LRFD $\phi = 0.75$	ASD $\Omega = 2.00$
$\phi P_n = (0.75)(216) = 162k$	$\frac{R_n}{\Omega} = \frac{216}{2.00} = 108k$

ANSWERS.

92.55k
LRFD

61.7k
ASD

✓ g.c.m.s

EXCLUSIVE: Just in Edutruth only

PROB # 12-28

Loads to be resisted

LRFD	ASD
$P_u = (1.2)(60) + (1.6)(90) = 216 \text{ k}$	$P_a = 60 + 90 = 150 \text{ k}$

Nominal strength of 1 bolt

From AISC Section J4.9 $\mu = 0.35$ for Class A surfaces, $D_u = 1.13$ multiplier, $h_{sc} = 1.00$ for standard size holes, $N_s = 2$ slip planes. Also from AISC Table J3.1 $T_b = 28 \text{ k}$.

$$R_n = \mu D_u h_{sc} T_b N_s = (0.35)(1.13)(1.00)(28)(2) = 22.15 \text{ k}$$

slip critical design for serviceability limit state

LRFD $\phi = 1.00$	ASD $\Omega = 1.50$
$\phi R_n = (1.00)(22.15) = 22.15 \text{ k}$	$\frac{R_n}{\Omega} = \frac{22.15}{1.50} = 14.77 \text{ k}$
No. of bolts reqd = $\frac{216}{22.15} = 9.75$	No. of bolts reqd = $\frac{150}{14.77}$
<u>Say 10 bolts</u>	<u>= 10.16 Say 11 or 12 bolts</u>

Bearing strength of 10 bolts

$$L_c = 1.50 \text{ in.}$$

$$\begin{aligned} \text{Total } R_n \text{ for 10 bolts} &= (10)(1.2 L_c \leq F_u) \leq (10)(2.4 d \leq F_u) \\ &= (10)(1.2)(1.5)(1.0)(58) = 1044 \text{ k} = (10)(2.4 \times \frac{3}{4} \times 1 \times 58) = 1044 \text{ k} \end{aligned}$$

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EXCLUSIVE: Just in Edutruth only

PROB #12-28 CONTD.

LRFD $\phi = 0.75$	ASD $\Omega = 2.00$
$\phi R_m = (0.75)(1044) = 783k > 216k$ <u>OK</u>	$\frac{R_m}{\Omega} = \frac{1044}{2.00} = 522k > 150k$ <u>OK</u>

Shearing strength of 10 bolts

$$\text{Total } R_m = 10 F_m A_b = (10)(60)(2 \times 0.44) = 528k$$

LRFD $\phi = 0.75$	ASD $\phi = 2.00$
$\phi R_m = (0.75)(528) = 396k > 216k$ <u>OK</u>	$\frac{R_m}{\Omega} = \frac{528}{2.00} = 264k > 150k$ <u>OK</u>

ANSWERS.

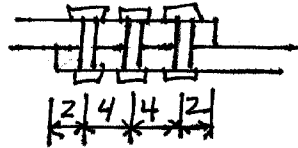
USE 10 - $\frac{3}{4}$ -in A325
slip critical bolts
for LRFD

USE 11 or 12 - $\frac{3}{4}$ -in. A325
slip critical bolts
for ASD

✓ JCM

EXCLUSIVE: Just in Edutruth only

PROB #12-29



Loads to be resisted

LRFD	ASD
$P_u = (1.2)(50) + (1.6)(100) = 220 \text{ k}$	$P_a = 50 + 100 = 150 \text{ k}$

Nominal strength of 1 bolt

From AISC Section J4.9 $\mu = 0.35$ for Class A surface, $D_u = 1.13$ multiplier, $h_{sc} = 1.00$ for standard size holes, $N_s = 1$ slip plane. Also from AISC Table J3.1 $T_b = 39 \text{ k}$.

$$R_n = \mu D_u h_{sc} T_b N_s = (0.35)(1.13)(1.00)(39)(1) = 15.42 \text{ k}$$

Slip critical design for serviceability limit state

LRFD $\phi = 1.00$	ASD $\Omega = 1.50$
$\phi R_n = (1.00)(15.42) = 15.42 \text{ k}$ No of bolts reqd. $= \frac{220}{15.42}$ $= 14.26$ say 15	$\frac{R_n}{\Omega} = \frac{15.42}{1.50} = 10.28$ No of bolts reqd. $= \frac{150}{10.28}$ $= 14.59$ say 15

Bearing strength of bolts

L_c given $= 1.5 \text{ in.}$

$$\begin{aligned}
 R_n \text{ for 15 bolts} &= (15)(1.2 L_c \leq F_u) = (15)(1.2)(1.5)\left(\frac{5}{8}\right)(58) \\
 &= 978.7 \text{ k} < (15)(2.4 d \leq F_u) = (15)(2.4)\left(\frac{7}{8}\right)\left(\frac{5}{8}\right)(58) \\
 &= 1141.9 \text{ k}
 \end{aligned}$$

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EXCLUSIVE: Just in Edutruth only

PROB #12-29 CONTD.

LRFD $\phi = 0.75$	ASD $\Omega = 2.00$
$\phi R_m = (0.75)(978.7) = 734 \text{ k}$ $> 220 \text{ k}$ <u>OK</u>	$\frac{R_m}{\Omega} = \frac{978.7}{2.00} = 489.3 \text{ k} > 150 \text{ k}$ <u>OK</u>

Shear strength of 15 bolts

$$\text{Total } R_m = 15 F_m A_b = (15)(60)(0.60) = 540 \text{ k}$$

LRFD $\phi = 0.75$	ASD $\Omega = 2.00$
$\phi R_m = (0.75)(540) = 405 \text{ k}$ $> 220 \text{ k}$ <u>OK</u>	$\frac{R_m}{\Omega} = \frac{540}{2.00} = 270 \text{ k}$ $> 150 \text{ k}$ <u>OK</u>

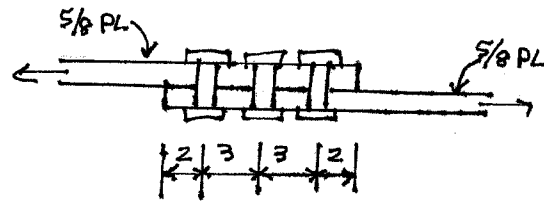
ANSWRS.

USE 15- $\frac{7}{8}$ -in A325 slip critical bolts
for both LRFD and ASD

✓ JCMC

EXCLUSIVE: Just in Edutruth only

PROB #12-30



Loads to be resisted

LRFD	ASD
$P_u = (1.2)(75) + (1.6)(160) = 346 \text{ k}$	$P_a = 75 + 160 = 235 \text{ k}$

Nominal strength of 1 bolt

From AISC Section J4.9 $\mu = 0.35$ for Class A surfaces, $D_u = 1.13$ multiplier, $h_{sc} = 1.00$ for standard size holes, $N_s = 1$ slip plane. Also from AISC Table J3.1 $T_b = 39 \text{ k}$.

$$R_n = \mu D_u h_{sc} T_b N_s = (0.35)(1.13)(1.00)(39)(1) = 15.42 \text{ k}$$

Slip critical design for serviceability limit state

LRFD $\phi = 1.00$	ASD $\Omega = 1.50$
$\phi R_n = (1.00)(15.42) = 15.42 \text{ k}$	$\frac{R_n}{\Omega} = \frac{15.42}{1.50} = 10.28 \text{ k}$
No. of bolts reqd. = $\frac{346}{15.42}$	No. of bolts reqd. = $\frac{235}{10.28}$
= 22.44 <u>Say 23 or 24 bolts</u>	= 22.86 <u>Say 23 or 24 bolts</u>

Bearing strength of 24 bolts

$$L_c = 1.50 \text{ in.}$$

$$\begin{aligned} \text{Total } R_n \text{ for 24 bolts} &= (24)(1.2 L_c \leq F_u) \\ &= (24)(1.2)(1.5)\left(\frac{5}{8}\right)(58) = 1566 \text{ k} < 24(2.4 d \leq F_u) \\ &= (24)(2.4)\left(\frac{7}{8}\right)\left(\frac{5}{8}\right)(58) = 1827 \text{ k} \end{aligned}$$

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EXCLUSIVE: Just in Edutruth only

PROB #12-30 CONTD.

LRFD $\phi = 0.75$	ASD $\Omega = 2.00$
$\phi R_n = (0.75)(1566) = 1174.5k > 346k$	$\frac{R_n}{\Omega} = \frac{1566}{2.00} = 783k > 235k$

Shearing strength of 24 bolts

$$\text{Total } R_n = 24 F_n A_s = (24)(48)(0.60) = 691.2k$$

LRFD $\phi = 0.75$	ASD $\Omega = 2.00$
$\phi R_n = (0.75)(691.2) = 518.4k > 346k$	$\frac{R_n}{\Omega} = \frac{691.2}{2.00} = 345.6k > 235k$

ANSWRS.

USE 24 - $\frac{7}{8}$ A325 slip
critical bolts
for LRFD

USE 24 - $\frac{7}{8}$ A325 slip
critical bolts for
ASD

✓ JCM

EXCLUSIVE: Just in Edutruth only

PROB # 12-31

Loads to be resisted

LRFD	ASD
$P_u = (1.2)(60) + (1.6)(80) = 200 \text{ k}$	$P_a = 60 + 80 = 140 \text{ k}$

From AISC Section J4.9 $\mu = 0.35$ for Class A surface, $D_u = 1.13$ multiplier, $h_{sc} = 1.00$ for standard size holes, $N_s = 2$ slip planes. Also from AISC Table J3.1 $T_b = 39 \text{ ksi}$.

$$R_m = \mu D_u h_{sc} T_b N_s = (0.35)(1.13)(1.00)(39)(2) = 30.85 \text{ k}$$

Slip critical design for serviceability limit state

LRFD $\phi = 1.00$	ASD $\Omega = 1.50$
$\phi R_m = (1.00)(30.85) = 30.85 \text{ k}$ No. of bolts reqd. = $\frac{200}{30.85}$ = 6.48 <u>Say 7 bolts</u>	$\frac{R_m}{\Omega} = \frac{30.85}{1.50} = 20.57 \text{ k}$ No. of bolts reqd. = $\frac{140}{20.57}$ = 6.81 <u>Say 7 bolts</u>

Bearing strength of 7 bolts

L_c given = 1.50 in.

$$\begin{aligned} \text{Total } R_m \text{ for 7 bolts} &= (7)(1.2 L_c F_u) = (7)(1.2)(1.5)\left(\frac{3}{4}\right)(58) \\ &= \underline{548.1 \text{ k}} < (7)(2.4 d F_u) = (7)(2.4)\left(\frac{3}{8}\right)\left(\frac{3}{4}\right)(58) = 639.4 \text{ k} \end{aligned}$$

EXCLUSIVE: Just in Edutruth only

PROB #12-31 CONTD.

LRFD $\phi = 0.75$	ASD $\Omega = 2.00$
$\phi R_m = (0.75)(548.1) = 411.1 \text{ k}$ $> 200 \text{ k}$ <u>ok</u>	$\frac{R_m}{\Omega} = \frac{548.1}{2.00} = 274 \text{ k} > 140 \text{ k}$ <u>ok</u>

Shearing strength of 7 bolts

$$\text{Total } R_m = 7 F_m A_b = (7)(60)(2 \times 0.6) = 504 \text{ k}$$

LRFD $\phi = 0.75$	ASD $\Omega = 2.00$
$\phi R_m = (0.75)(504) = 378 \text{ k} > 200 \text{ k}$ <u>ok</u>	$\frac{R_m}{\Omega} = \frac{504}{2.00} = 252 \text{ k} > 140 \text{ k}$ <u>ok</u>

ANSWRS.

USE 7- $\frac{7}{8}$ slip critical
A325 bolts for
both LRFD and ASD

✓ gcm

EXCLUSIVE: Just in Edutruth only

PROB #12-32

Loads to be resisted

LRFD	ASD
$P_u = (1.2)(40) + (1.6)(100) = 208 \text{ k}$	$P_a = 40 + 100 = 140 \text{ k}$

Nominal strength of 1 bolt

From AISC Section J4.9 $\mu = 0.35$ for Class A surface, $D_u = 1.13$ multiplier, $h_{sc} = 1.00$ hole factor for standard size holes, $N_s = 2$ slip planes. Also from AISC Table J3.1 $T_b = 56 \text{ k}$.

$$R_n = \mu D_u h_{sc} T_b N_s = (0.35)(1.13)(1.00)(56)(2) = 44.30 \text{ k}$$

Slip Critical design for serviceability limit state

LRFD $\phi = 1.00$	ASD $\Omega = 1.50$
$\phi R_n = (1.00)(44.30) = 44.30 \text{ k}$	$\frac{R_n}{\Omega} = \frac{44.30}{1.50} = 29.53 \text{ k}$
No. of bolts reqd. = $\frac{208}{44.30}$ = 4.70 <u>Say 5</u>	No. of bolts reqd. = $\frac{140}{29.53}$ = 4.74 <u>Say 5</u>

Bearing strength of 5 bolts

L_c given = 1.50 in.

$$\begin{aligned} \text{Total } R_m \text{ for 5 bolts} &= (5)(1.2)(58) = (5)(1.2)(1.5)\left(\frac{3}{4}\right)(58) = 391.5 \text{ k} \\ &< (5)(2.4 d t R_u) = (5)(2.4 \times 1 \frac{1}{8})\left(\frac{3}{4}\right)(58) = 587.2 \text{ k} \end{aligned}$$

EXCLUSIVE: Just in Edutruth only

PROB# 12-32 CONTD.

LRFD $\phi = 0.75$	ASD $\Omega = 2.00$
$\phi R_m = (0.75)(391.5) = 293.6k > 208k$ <u>OK</u>	$\frac{R_m}{\Omega} = \frac{391.5}{2.00} = 195.7k > 140k$ <u>OK</u>

Shearing strength of 5 bolts

$$\text{Total } R_m = 5 F_m A_b = (5)(60)(0.994 \times 2) = 596.4k$$

LRFD $\phi = 0.75$	ASD $\Omega = 2.00$
$\phi R_m = (0.75)(596.4) = 447.3k$ $> 208k$ <u>OK</u>	$\frac{R_m}{\Omega} = \frac{596.4}{2.00} = 298.2k > 140k$ <u>OK</u>

ANSWERS.

USE 5 $\rightarrow 1\frac{1}{8}$ A325 slip critical bolts for both LRFD and ASD

✓ JCM

EXCLUSIVE: Just in Edutruth only

PROB#12-33

Loads to be resisted

LRFD	ASD
$P_u = 360 \text{ k}$	$P_a = 260 \text{ k}$

Nominal strength of 1 bolt

From AISC Section J4.9 $\mu = 0.35$ for Class A surface, $D_u = 1.13$ multiplier, $h_{sc} = 1.00$ for standard size holes, N_s assumed equal to 2 slip planes. Also from AISC Table J3.1 $T_b = 51 \text{ k}$.

$$R_n = \mu D_u h_{sc} T_b N_s = (0.35)(1.13)(1.00)(51)(2) = 40.34 \text{ k}$$

Slip Critical design for serviceability

LRFD $\phi = 1.00$	ASD $\Omega = 1.50$
$\phi R_n = (1.00)(40.34) = 40.34 \text{ k}$	$\frac{R_n}{\Omega} = \frac{40.34}{1.50} = 26.89 \text{ k}$
No. of bolts reqd. $= \frac{360}{40.34} = 8.92$ <u>Say 9 bolts</u>	No. of bolts reqd. $= \frac{260}{26.89} = 9.67$ <u>Say 10 bolts</u>

Bearing strength of 9 bolts

L_e given = 1.50 in.

$$\begin{aligned} \text{Total } R_n &= (9)(1.2 L_e F_u) > (9)(1.2)(1.5)(1.75)(58) = \underline{1644.3 \text{ k}} \\ &< (9)(2.4 d F_u) = (9)(2.4)(1.00)(1.75)(58) = 2192 \text{ k} \end{aligned}$$

EXCLUSIVE: Just in Edutruth only

PROB # 12-33 CONTD.

Shearing strength of 9 bolts

$$\text{Total } R_m = 9F_m A_b = (9)(60)(2 \times 0.785) = 847.8 \text{ k}$$

LRFD $\phi = 0.75$	ASD $\Omega = 2.00$
$\phi R_m = (0.75)(847.8) = 635.85 \text{ k}$ $> 360 \text{ k}$ <u>OK</u>	$\frac{R_m}{\Omega} = \frac{847.8}{2.00} = 423.9 \text{ k} > 260 \text{ k}$ <u>OK</u>

ANSWRS.

USE 9-1/2 in. A325
slip critical bolts
For LRFD

USE 10-1/2 in. A325
slip critical bolts
For ASD

✓ g c m c

EXCLUSIVE: Just in Edutruth only

PROB #12-34

From AISC Section J4.9 $\mu = 0.35$ for Class A surface, $D_u = 1.13$ multiplier, $h_{sc} = 0.70$ hole factor for long slotted holes, $N_s = 1$ slip plane. Also from AISC Table J3.1 $T_b = 51 \text{ k}$.

$$R_m = \mu D_u h_{sc} T_b N_s = (0.35)(1.13)(0.70)(51)(1) = 14.12 \text{ k}$$

LRFD $\phi = 0.85$	ASD $\Omega = 1.76$
$P_u = (1.2)(50) + (1.6)(100) = 220 \text{ k}$ $\phi R_m = (0.85)(14.12) = 12.00 \text{ k}$ $\text{No. of bolts reqd.} = \frac{220}{12.00}$ $= 18.33$	$P_a = 50 + 100 = 150 \text{ k}$ $\frac{R_m}{\Omega} = \frac{14.12}{1.76} = 8.02 \text{ k}$ $\text{No. of bolts reqd.}$ $= \frac{150}{8.02} = 18.70$

ANSWERS

USE 19 or 20 slip critical bolts for the reqd. strength level for both LRFD and ASD

Subsequents checks for bearing and shear ok

✓ gcm

EXCLUSIVE: Just in Edutruth only

PROB #12-35

From AISC Section J4.9 $\mu = 0.35$ for Class A surface, $D_u = 1.13$ multiplier, $h_{sc} = 0.70$ hole factor for long slotted holes, $N_s = 2$ slip planes. Also from AISC Table J3.1 $T_b = 51k$.

$$R_n = \mu D_u h_{sc} T_b N_s = (0.35)(1.13)(0.70)(51)(2) = 28.24k$$

LRFD $\phi = 0.85$	ASD $\Omega = 1.76$
$P_u = (1.2)(120) + (1.6)(150) = 384k$ $\phi R_n = (0.85)(28.24) = 24.00k$ No. of bolts reqd. $= \frac{384}{24.00} = 16$	$P_u = 120 + 150 = 270k$ $\frac{R_n}{\Omega} = \frac{28.24}{1.76} = 16.05k$ No. of bolts reqd. $= \frac{270}{16.05} = 16.82 \text{ bolts}$

ANSWERS.

USE 16-lin.
A325 slip critical
bolts for the reqd.
strength level
for LRFD

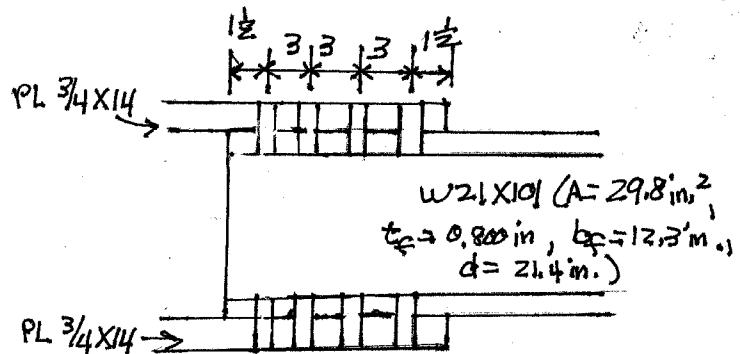
USE 17-lin.
A325 slip critical
bolts for the reqd.
strength level
for ASD

Subsequent checks for bearing, tension,
etc. OK

V GCMC

EXCLUSIVE: Just in Edutruth only

PROB # 12-36



(a) Tensile yielding of connecting elements

$$P_m = (36)(2)(\frac{3}{4} \times 14) = 756 \text{ k}$$

LRFD $\phi_t = 0.90$	ASD $\Omega_t = 1.67$
$\phi_t P_m = (0.90)(756) = 680.4 \text{ k}$	$\frac{P_m}{\Omega_t} = \frac{756}{1.67} = 452.7 \text{ k}$

(b) Tensile rupture of connecting elements

$$A_m \text{ of PLS} = (2) \left[\frac{3}{4} \times 14 - (2) \left(\frac{7}{8} + \frac{1}{8} \right) \left(\frac{3}{4} \right) \right] = 18.0 \text{ in}^2$$

or

$$0.85 A_g = (0.85)(2) \left(\frac{3}{4} \times 14 \right) = 17.85 \text{ in}^2$$

$u = 1.0$ for connecting plates

$$P_m = F_u A_e = (58)(1.0 \times 17.85) = 1035.3 \text{ k}$$

LRFD $\phi_t = 0.75$	ASD $\Omega_t = 2.00$
$\phi_t P_m = (0.75)(1035.3) = 776.5 \text{ k}$	$\frac{P_m}{\Omega_t} = \frac{1035.3}{2.00} = 517.6 \text{ k}$

(c) Tensile yielding of W section

$$P_m = (36)(29.8) = 1072.8 \text{ k}$$

LRFD $\phi_t = 0.90$	ASD $\Omega_t = 1.67$
$\phi_t P_m = (0.9)(1072.8) = 965.5 \text{ k}$	$\frac{P_m}{\Omega_t} = \frac{1072.8}{1.67} = 642.4 \text{ k}$

(d) Tensile rupture strength of W section

$$A_m = 29.8 - (4) \left(\frac{7}{8} + \frac{1}{8} \right) (0.800) = 26.6 \text{ in}^2$$

$$\bar{x} = \bar{y} = 2.18 \text{ in. for WT10.5 x 50.5}$$

$$u = 1 - \frac{\bar{x}}{L} = 1 - \frac{2.18}{3 \times 3} = 0.76$$

$$b_e = 12.3 < \frac{2}{3} d = \frac{2}{3} \times 21.4 = 14.27 \text{ in.}$$

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EXCLUSIVE: Just in Edutruth only

PROB# 12-36 CONTD.

$$\therefore \mu = 0.85 \text{ (Case 7 AISC Table D3.1)}$$

$$P_m = F_u A_g = (58)(0.85 \times 26.6) = 1311.4 \text{ k}$$

LRFD $\phi_t = 0.75$	ASD $\Omega_t = 2.00$
$\phi_t P_m = (0.75)(1311.4) = 983.5 \text{ k}$	$\frac{P_m}{\Omega_t} = \frac{1311.4}{2.00} = 655.7 \text{ k}$

(e) Bolts in SS & Bearing on $\frac{3}{4}$ in.

SS strength of 16 bolts

$$R_m = F_m A_b = (16)(60)(0.60) = 576 \text{ k}$$

LRFD $\phi = 0.75$	ASD $\Omega = 2.00$
$\phi R_m = (0.75)(576) = 432 \text{ k}$	$\frac{R_m}{\Omega} = \frac{576}{2.00} = 288 \text{ k}$

Bearing strength of 16 bolts

$$L_c = 1.5 - \frac{1}{2} \left(\frac{7}{8} + \frac{1}{8} \right) = 1.00 \text{ in.}$$

$$R_m = 1.2 L_c t F_u \leq 2.4 d t F_u$$

$$R_m = (1.2)(1.00) \left(\frac{3}{4} \right) (58)(16) = 835.2 \text{ k} < (2.4) \left(\frac{7}{8} \right) \left(\frac{3}{4} \right) (58)(16) = 1461.6 \text{ k}$$

LRFD $\phi = 0.75$	ASD $\Omega = 2.00$
$\phi_t R_m = (0.75)(835.2) = 626.4 \text{ k}$	$\frac{R_m}{\Omega} = \frac{835.2}{2.00} = 417.6 \text{ k}$

(f) Block shear strength considering both flanges

$$A_{gv} = (4)(10.5)(0.800) = 33.6 \text{ in.}^2$$

$$A_{nv} = (4) \left[10.5 - (3.5) \left(\frac{7}{8} + \frac{1}{8} \right) \right] (0.800) = 22.4 \text{ in.}^2$$

$$A_{nt} = (4) \left[3.4 - \left(\frac{1}{2} \right) \left(\frac{7}{8} + \frac{1}{8} \right) \right] (0.800) = 9.28 \text{ in.}^2$$

$$U_{bs} = 1.0$$

$$R_m = (0.6)(F_u)(A_{nv}) + U_{bs} F_u A_{nt} \leq 0.6 F_y A_{gv} + U_{bs} F_u A_{nt}$$

$$R_m = (0.6)(58)(22.4) + (1.0)(58)(9.28) = 1317.8 \text{ k} > (0.6)(36)(33.6) + (1.0)(58)(9.28) = 1264 \text{ k}$$

LRFD $\phi = 0.75$	ASD $\Omega = 2.00$
$\phi R_m = (0.75)(1264) = 948 \text{ k}$	$\frac{R_m}{\Omega} = \frac{1264}{2.00} = 632 \text{ k}$

ANSWERS. 432 k LRFD 288 k ASD

✓ g C MC

EXCLUSIVE: Just in Edutruth only

PROB# 12-37

Sketch same as
for Prob #12-36

(a) Tensile yielding of connecting elements

$$P_m = (50)(2)\left(\frac{3}{4} \times 14\right) = 1050 \text{ k}$$

LRFD $\phi_t = 0.90$	ASD $\Omega_t = 1.67$
$\phi_t P_m = (0.90)(1050) = 945 \text{ k}$	$\frac{P_m}{\Omega_t} = \frac{1050}{1.67} = 628.7 \text{ k}$

(b) Tensile rupture of connecting elements

$$A_m \text{ of PLs} = (2)\left[\frac{3}{4} \times 14 - (2)\left(1 + \frac{1}{8}\right)\left(\frac{3}{4}\right)\right] = 17.625 \text{ in}^2$$

$$\text{or } 0.85 A_g = (0.85)(2)\left(\frac{3}{4} \times 14\right) = 17.85 \text{ in}^2$$

$U = 1.0$ for connecting plates

$$P_m = F_u A_e = (65)(1.0 \times 17.625) = 1145.6 \text{ k}$$

LRFD $\phi_t = 0.75$	ASD $\Omega_t = 2.00$
$\phi_t P_m = (0.75)(1145.6) = 859.2 \text{ k}$	$\frac{P_m}{\Omega_t} = \frac{1145.6}{2.00} = 572.8 \text{ k}$

(c) Tensile yielding of W section

$$P_m = (50)(29.8) = 1490 \text{ k}$$

LRFD $\phi_t = 0.90$	ASD $\Omega_t = 1.67$
$\phi_t P_m = (0.90)(1490) = 1341 \text{ k}$	$\frac{P_m}{\Omega_t} = \frac{1490}{1.67} = 892.2 \text{ k}$

(d) Tensile rupture strength of W section

$$A_m = 29.8 - (4)\left(1 + \frac{1}{8}\right)(0.800) =$$

$$\bar{x} = \bar{y} \text{ for WT } 10.5 \times 50.5 = 2.18 \text{ in.}$$

$$U = 1 - \frac{\bar{x}}{L} = 1 - \frac{2.18}{3 \times 3} = 0.76$$

$$b_f = 12.3 < \frac{2}{3}d = \frac{2}{3} \times 21.4 = 14.27 \text{ in}$$

$\therefore U = 0.85$ (Case 7 AISC Table D3.1)

$$P_m = F_u A_e = (65)(0.85 \times 26.2) = 1447.5 \text{ k}$$

EXCLUSIVE: Just in Edutruth only

PROB# 12-37 CONTD.

LRFD $\phi_t = 0.75$	ASD $\Omega_t = 2.00$
$\phi_t P_n = (0.75)(1447.5) = 1085.6 \text{ k}$	$\frac{P_n}{\Omega_t} = \frac{1447.5}{2.00} = 723.7 \text{ k}$

(e) Bolts in SS & Bearing on $\frac{3}{4}$ in.

SS strength of 16 bolts

$$R_n = F_n A_b = (16)(60)(0.785) = 753.6 \text{ k}$$

LRFD $\phi = 0.75$	ASD $\Omega = 2.00$
$\phi R_n = (0.75)(753.6) = 565.2 \text{ k}$	$\frac{R_n}{\Omega} = \frac{753.6}{2.00} = 376.8 \text{ k}$

Bearing strength of 16 bolts

$$L_c = 1.5 - \left(\frac{1}{2}\right)\left(1 + \frac{1}{8}\right) = 0.9375 \text{ in.}$$

$$R_n = 1.2 L_c t F_u \leq 2.4 d t F_u$$

$$R_n = (1.2)(0.9375)\left(\frac{3}{4}\right)(65)(16) = 877.5 \text{ k} < (2.4)(1)\left(\frac{3}{4}\right)(65)(16) = 1872 \text{ k}$$

LRFD $\phi = 0.75$	ASD $\Omega = 2.00$
$\phi_t R_n = (0.75)(877.5) = 658.1 \text{ k}$	$\frac{R_n}{\Omega} = \frac{877.5}{2.00} = 438.7 \text{ k}$

(f) Block shear strength considering both flanges

$$A_{gv} = (4)(10.5)(0.800) = 33.6 \text{ in.}^2$$

$$A_{nv} = (4)\left[10.5 - \left(3.5\right)\left(1 + \frac{1}{8}\right)\right](0.800) = 21 \text{ in.}^2$$

$$A_{nt} = (4)\left[3.4 - \left(\frac{1}{2}\right)\left(1 + \frac{1}{8}\right)\right](0.800) = 9.08 \text{ in.}^2$$

$$U_{bs} = 1.0$$

$$R_n = 0.6 F_u A_{nv} + U_{bs} F_u A_{nt} \leq 0.6 F_y A_{gv} + U_{bs} F_u A_{nt}$$

$$R_n = (0.6)(65)(21) + (1.0)(65)(9.08) = 1409.2 < (0.6)(50)(33.6) + (1.0)(65)(9.08) = 1598.2$$

Sketch same as for Prob# 12-36

LRFD $\phi = 0.75$	ASD $\Omega = 2.00$
$\phi R_n = (0.75)(1409.2) = 1056.9 \text{ k}$	$\frac{R_n}{\Omega} = \frac{1409.2}{2.00} = 704.6 \text{ k}$

ANSWERS. 565.2 k LRFD 376.8 k ASD

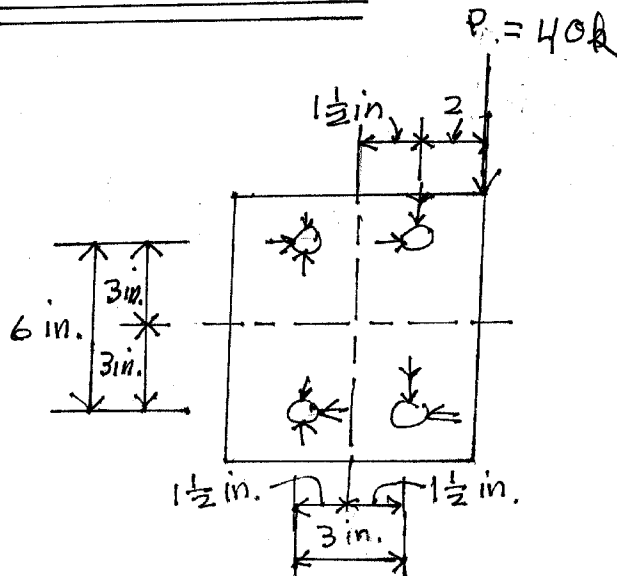
WJCMC

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EXCLUSIVE: Just in Edutruth only

CHAPTER 13

PROB #13-1



$$M = P e = (40)(3.5) = 140 \text{ in.} \cdot \text{k} \rightarrow$$

$$\sum d^2 = \sum h^2 + \sum b^2 = (4)(1.5)^2 + (4)(3)^2 = 45 \text{ in.}^2$$

Upper right and lower right bolts most stressed

$$H = \frac{M b}{\sum d^2} = \frac{(140)(3)}{45} = 9.33 \text{ k} \rightarrow$$

$$V = \frac{M h}{\sum d^2} = \frac{(140)(1.5)}{45} = 4.67 \text{ k} \downarrow$$

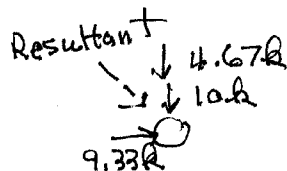
For upper right bolt

$$\frac{P}{4} = \frac{40}{4} = 10 \text{ k} \downarrow$$

$$\text{Resultant force} = \sqrt{(9.33)^2 + (4.67 + 10)^2}$$

$$= 17.39 \text{ k}$$

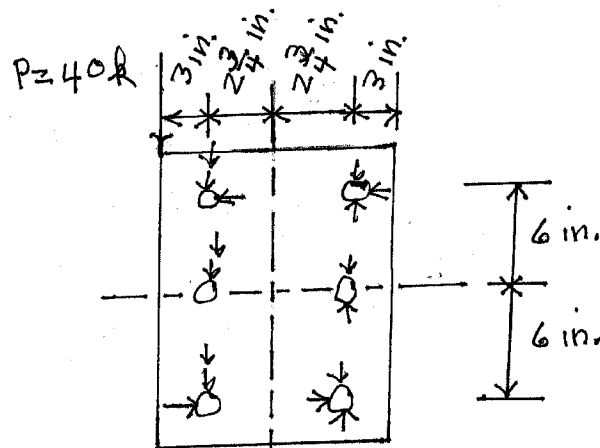
✓ JCM



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EXCLUSIVE: Just in Edutruth only

PROB #13-2



$$M = Pe = (40)(3 + 2.75) = 230 \text{ in.} \cdot k \quad \curvearrowright$$

$$\sum d^2 = \sum h^2 + \sum v^2 = (6)(2.75)^2 + (4)(6)^2 = 189.375 \text{ in.}^2$$

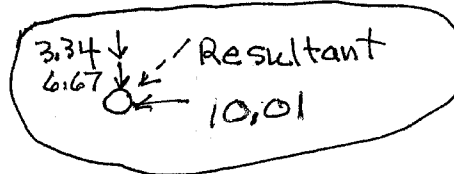
Upper left and lower left bolts most stressed

$$H = \frac{Mv}{\sum d^2} = \frac{(230)(6)}{189.375} = 7.29 k \leftarrow \text{For upper left bolt}$$

$$V = \frac{Mh}{\sum d^2} = \frac{(230)(2.75)}{189.375} = 3.34 k \downarrow$$

$$\frac{P}{6} = \frac{40}{6} = 6.67 k \downarrow$$

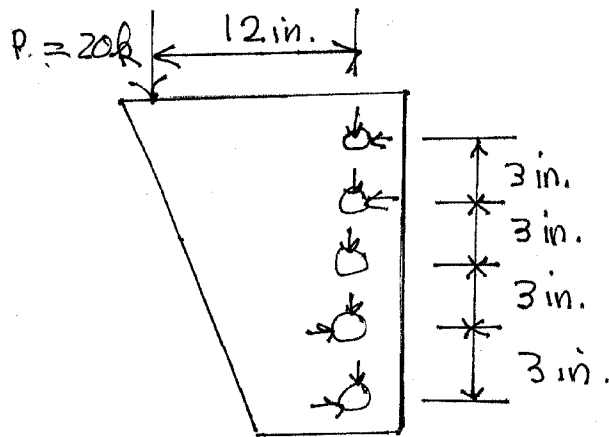
$$\text{Resultant force} = \sqrt{7.29^2 + (6.67 + 3.34)^2} = 12.38 k$$



✓ gcm =

EXCLUSIVE: Just in Edutruth only

PROB #13-3



$$M = P_e = (20)(12) = 240 \text{ in. k}$$

$$I_d^2 = I_u^2 = (2)(3)^2 + (2)(6)^2 = 90 \text{ in.}^2$$

Top and bottom bolts most stressed

$$H = \frac{M_u}{I_d^2} = \frac{(240)(6)}{90} = 16 \text{ k} \rightarrow$$

$$V = \frac{M_h}{I_d^2} = \frac{(240)(0)}{90} = 0$$

} For top bolt

$$\frac{P}{5} = \frac{20}{5} = 4 \text{ k} \downarrow$$

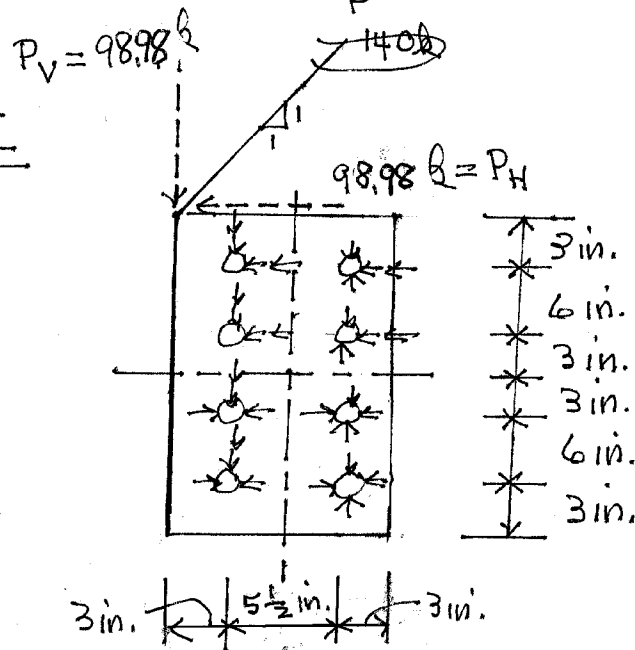
4k ↓ — Resultant
16k →

$$\text{Resultant} = \sqrt{(16)^2 + (4)^2} = \boxed{16.49 \text{ k}}$$

✓ gcm

EXCLUSIVE: Just in Edutruth only

PROB # 13-4



$$M = (98.98)(3 + 2.75) + (98.98)(3 + 6 + 3) = 1756.89 \text{ in. k}$$

$$\begin{aligned} \sum d^2 &= \sum h^2 + \sum v^2 = (8)(2.75)^2 + (4)(3)^2 + (4)(9)^2 \\ &= 420.5 \text{ in.}^2 \end{aligned}$$

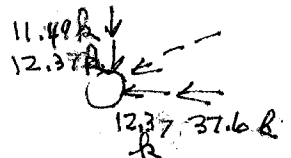
Upper left bolt most stressed

$$H = \frac{Mv}{\sum d^2} = \frac{(1756.89)(9)}{420.5} = 37.60 \text{ k} \leftarrow$$

$$V = \frac{Mh}{\sum d^2} = \frac{(1756.89)(2.75)}{420.5} = 11.49 \text{ k} \downarrow$$

$$\frac{P_H}{8} = \frac{98.98}{8} = 12.37 \text{ k} \leftarrow$$

$$\frac{P_V}{8} = \frac{98.98}{8} = 12.37 \text{ k} \downarrow$$



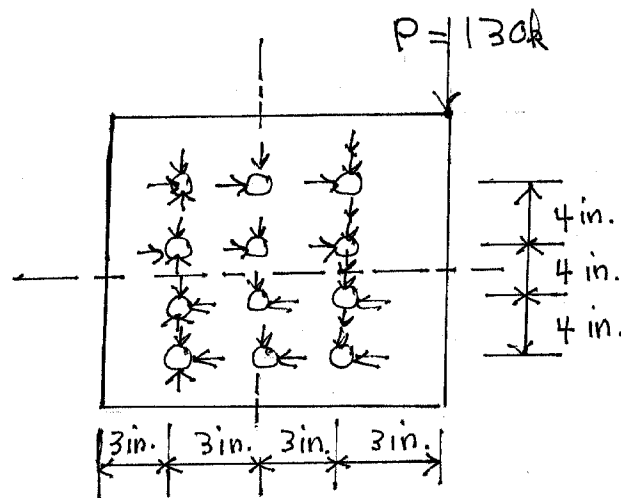
$$\begin{aligned} \text{Resultant} &= \sqrt{(37.60 + 12.37)^2 + (11.49 + 12.37)^2} \\ &= \boxed{55.37 \text{ k}} \end{aligned}$$

✓ JCMC

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EXCLUSIVE: Just in Edutruth only

PROB # 13-5



$$M = (130)(3+3) = 780 \text{ in. k} \rightarrow$$

$$\Sigma d^2 = \Sigma h^2 + \Sigma v^2 = (8)(3)^2 + (6)(2)^2 + (6)(6)^2 = 312 \text{ in.}^2$$

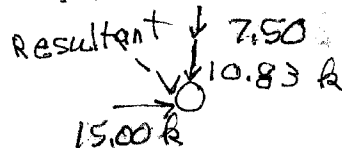
Upper right and lower right bolts most stressed

$$H = \frac{Mv}{\Sigma d^2} = \frac{(780)(6)}{312} = 15.00 \text{ k} \rightarrow$$

$$V = \frac{Mh}{\Sigma d^2} = \frac{(780)(3)}{312} = 7.50 \text{ k} \downarrow$$

} For upper right bolt

$$\frac{P}{12} = \frac{130}{12} = 10.83 \text{ k} \downarrow$$



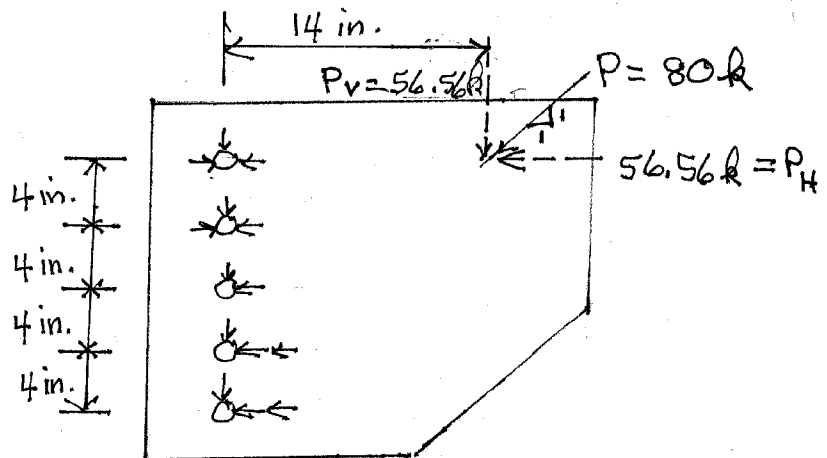
$$\text{Resultant} = \sqrt{(15.00)^2 + (7.50 + 10.83)^2}$$

$$= \boxed{23.69 \text{ k}}$$

✓ JCMC

EXCLUSIVE: Just in Edutruth only

PROB # 13-6



$$M = (56.56)(14) - (56.56)(8) = 339.36 \text{ in.-k} \downarrow$$

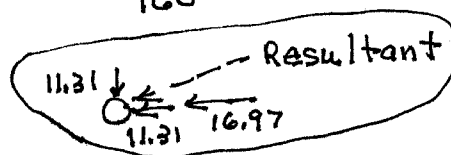
$$\Sigma d^2 = (2)(4)^2 + (3)(8)^2 = 160 \text{ in.}^2$$

Bottom bolt most stressed

$$\frac{P_V}{5} = \frac{56.56}{5} = 11.31 \text{ k} \downarrow$$

$$\frac{P_H}{5} = \frac{56.56}{5} = 11.31 \text{ k} \leftarrow$$

$$H = \frac{M \cdot d}{\Sigma d^2} = \frac{(339.36)(8)}{160} = 16.97 \text{ k} \leftarrow$$



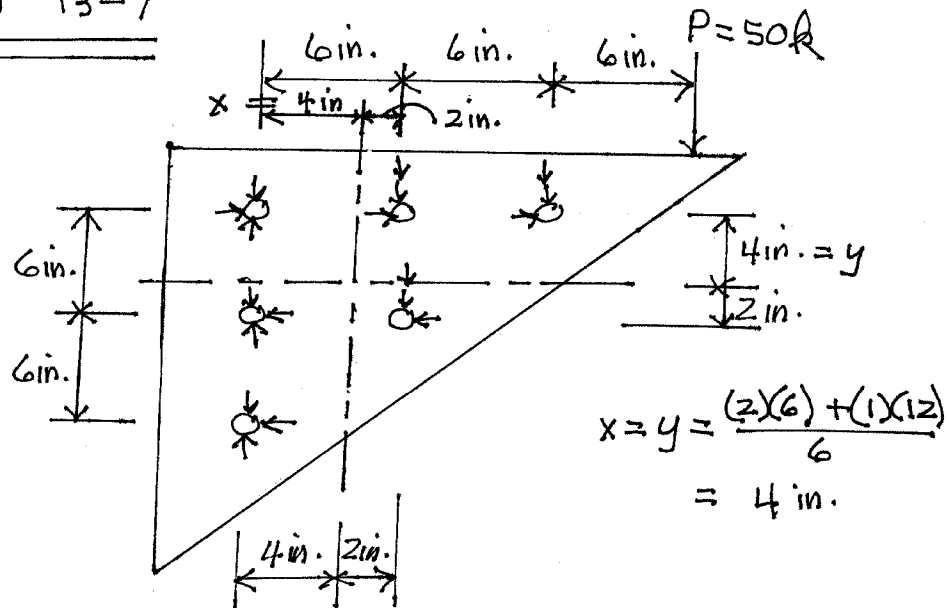
$$\text{Resultant} = \sqrt{(11.31)^2 + (11.31 + 16.97)^2}$$

$$= \boxed{30.46 \text{ k}}$$

✓ gmc

EXCLUSIVE: Just in Edutruth only

PROB # 13-7



$$M = Pe = (50)(14) = 700 \text{ in. k} \rightarrow$$

$$\sum d^2 = [\sum h^2 = (3)(4)^2 + (2)(2)^2 + (1)(8)^2] 2 = 240 \text{ in.}^2$$

Upper far right bolt most stressed

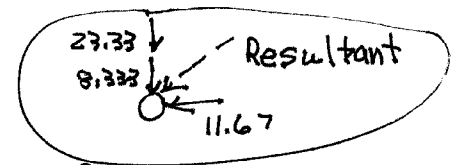
$$\frac{P}{6} = \frac{50}{6} = 8.333 \text{ k} \downarrow$$

$$H = \frac{Mx}{\sum d^2} = \frac{(700)(4)}{240} = 11.67 \text{ k} \rightarrow$$

$$V = \frac{My}{\sum d^2} = \frac{(700)(8)}{240} = 23.33 \text{ k} \downarrow$$

$$\text{Resultant force} = \sqrt{(11.67)^2 + (8.333 + 23.33)^2}$$

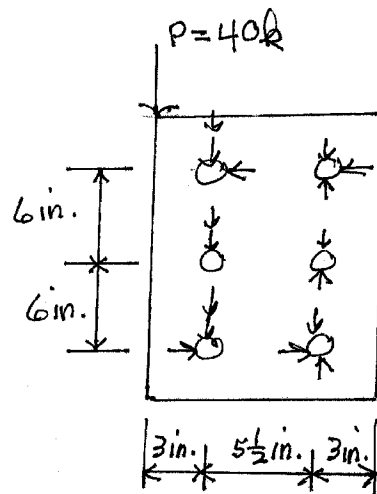
$$= \boxed{33.75 \text{ k}}$$



✓ JCM

EXCLUSIVE: Just in Edutruth only

PROB #13-8



$$e_{\text{effective}} = e_{\text{actual}} - \frac{1+m}{3}$$

$$= 5.75 - \frac{1+3}{2} = 3.75 \text{ in.}$$

$$M = (40)(3.75) = 150 \text{ in.-k}$$

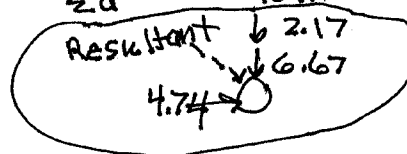
$$I_d^2 = I_h^2 + I_v^2 = (4)(6)^2 + (6)(2.75)^2 = 189.75 \text{ in.}^2$$

Lower left bolt most stressed

$$\frac{P}{6} = \frac{40}{6} = 6.67 \text{ k} \downarrow$$

$$H = \frac{Mv}{I_d^2} = \frac{(150)(6)}{189.75} = 4.74 \text{ k} \rightarrow$$

$$V = \frac{Mh}{I_d^2} = \frac{(150)(2.75)}{189.75} = 2.17 \text{ k} \downarrow$$



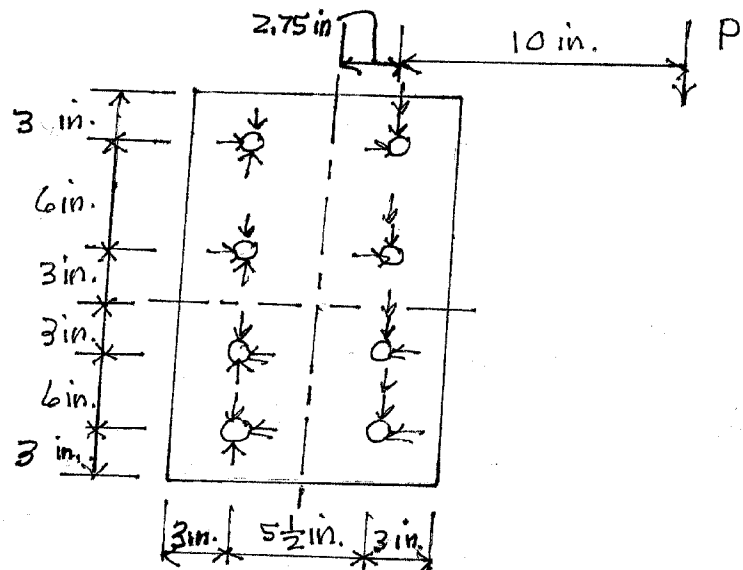
$$\text{Resultant} = \sqrt{(4.74)^2 + (6.67 + 2.17)^2}$$

$$= \boxed{10.03 \text{ k}}$$

✓ JCM

EXCLUSIVE: Just in Edutruth only

PROB #13-9



$$M = (P)(12.75) = 12.75 P_u \downarrow$$

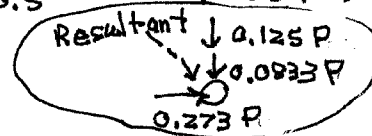
$$\sum d^2 = \sum h^2 + \sum u^2 = (8)(2.75)^2 + (4)(3)^2 + (4)(9)^2 = 420.5 \text{ in.}^2$$

Upper right and lower right bolts most stressed

$$H = \frac{Mu}{\sum d^2} = \frac{(12.75 P_u)(9)}{420.5} = 0.273 P \rightarrow$$

$$V = \frac{Mh}{\sum d^2} = \frac{(12.75 P_u)(2.75)}{420.5} = 0.0833 P \downarrow$$

$$\frac{P}{8} = 0.125 P \downarrow$$



$$\text{Resultant} = \sqrt{(0.273 P)^2 + (0.0833 P + 0.125 P)^2}$$

$$= 0.3434 P$$

Bolts in SS and bearing on $\frac{5}{8}$ in.

Bearing strength of 1 bolt

$$L_c = 3 - \frac{\frac{3}{4} + \frac{1}{8}}{2} = 2.56 \text{ in.}$$

EXCLUSIVE: Just in Edutruth only

PROB # 13-9 CONTD.

$$R_m = 1.2L_e t F_u (\text{No of bolts}) \geq 2.4 d t F_u (\text{No of bolts})$$

$$= (1.2)(2.56)(\frac{5}{8})(58)(1) = 111.4k > (2.4)(\frac{3}{4})(\frac{5}{8})(58)(1) = 65.2k$$

Shearing strength of 1 bolt

$$R_m = (0.44)(60) = 26.4k \leftarrow$$

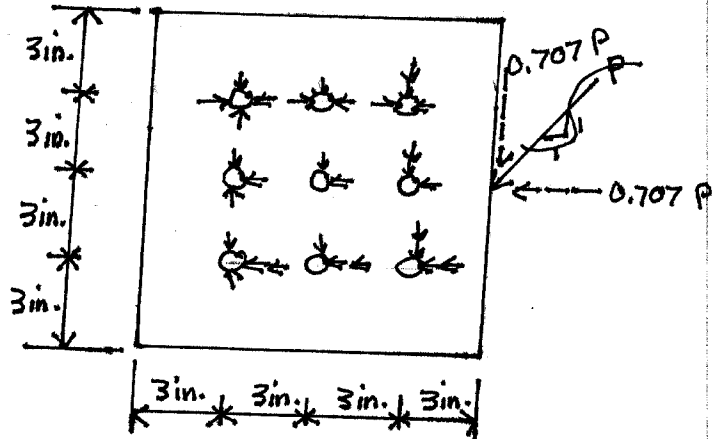
LRFD	ASD
$\phi R_m = (0.75)(26.4) = 19.8k$	$\frac{R_m}{\Omega} = \frac{26.4}{2.00} = 13.2k$
$0.3434 P_u =$	$0.3434 P_a = 13.2k$
<u>$P_u = 57.7k$</u>	<u>$P_a = 38.4k$</u>

$\checkmark \phi R_m \geq$

EXCLUSIVE: Just in Edutruth only

PROB #13-10

(a) Elastic Analysis



Lower right bolt most stressed

$$M = (0.707P)(6) = 4.242P \downarrow$$

$$\sum d^2 = \sum h^2 + \sum v^2 = (6)(3)^2 + (6)(3)^2 = 108$$

$$H = \frac{Mv}{\sum d^2} = \frac{(4.242P)(3)}{108} = 0.118P \leftarrow$$

$$V = \frac{Mh}{\sum d^2} = \frac{(4.242P)(3)}{108} = 0.118P \downarrow$$

$$\frac{0.707P}{9} = 0.0786P \downarrow$$

$$\frac{0.707P}{9} = 0.0786P \leftarrow$$

$$\text{Result. } R = \sqrt{(0.118P + 0.0786P)^2(2)} = 0.278P$$

(b) Slip critical bolts (serviceability limit state)

Nominal strength of 1 slip critical $\frac{7}{8}$ bolt in D.S.

$$\phi R_n = \phi D_u h s A T_b N_s$$

$$= (0.35)(1.13)(1.00)(39)(2) = 30.85k$$

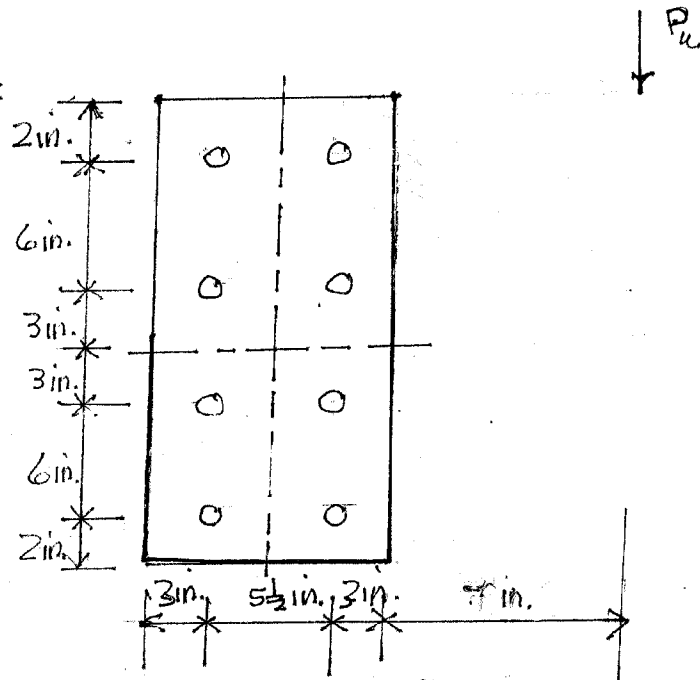
✓ GCMSE

LRFD $\phi = 1.00$	ASD $\Omega = 1.50$
$\phi R_n = (1.00)(30.85) = 30.85k \text{ each}$	$\frac{R_n}{\Omega} = \frac{30.85}{1.50} = 20.57k \text{ each}$
$0.278 P_u = 30.85$	$0.278 P_a = 20.57$
$P_u = 111k$	$P_a = 74k$

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EXCLUSIVE: Just in Edutruth only

PROB # 13-11



Bolts in SS & bearing on $\frac{5}{8}$ in.

ϕR_n = nominal shear strength for 1 bolt

$$= (0.44)(60) = 26.4 \text{ k} \leftarrow$$

ϕR_n = nominal bearing strength of 1 bolt

$$L_c = 2 - \frac{3/4 + 1/8}{2} = 1.56 \text{ in.}$$

$$\phi R_n = 1.5 L_c \leq F_u \leq 2.4 d \leq F_u$$

$$(1.5)(1.56) \left(\frac{5}{8} \right) (58) = 84.9 \text{ k} > (2.4) \left(\frac{3}{4} \right) \left(\frac{5}{8} \right) (58) = \underline{\underline{65.25 \text{ k}}}$$

From AISC Table 7-9

$$e = 0$$

$$e_x = 10 + \frac{5.5}{2} = 12.75$$

$$S = 6$$

$$C = 3.50 \text{ from Table}$$

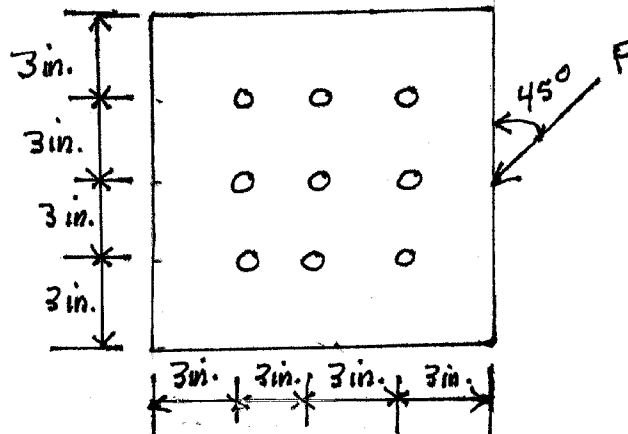
$$P_u = C \phi R_n = (3.50)(0.75 \times 26.4) = \boxed{69.3 \text{ k}}$$

Note: If P_u is desired its value is 46.2 k

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EXCLUSIVE: Just in Edutruth only

PROB# 13-12



For slip critical connection

$$\phi_m = (0.35)(1.13)(1.00)(39)(2) = 30.85 \text{ k}$$

using AISC Table 7-12 (page 7-59)

$$e_x = 6 \text{ in.}$$

$$d = 3 \text{ in.}$$

$$C = 4.78$$

$$R_m = C \times \phi_m = (4.78)(30.85) = 147.46 \text{ k}$$

$$\frac{R_m}{\Omega} = \frac{147.46}{2.00} = \boxed{73.7 \text{ k}}$$

✓ gcm

EXCLUSIVE: Just in Edutruth only

PROB# 13-13

L RFD $\phi = 0.75$	ASD $\Omega = 2.00$
$P_u = 200 \text{ k}$ $V_u = \left(\frac{3}{5}\right)(200) = 120 \text{ k}$ $H_u = \left(\frac{4}{5}\right)(200) = 160 \text{ k}$ $F_{mt} = 90 \text{ ksi}$ $F_{mv} = 60 \text{ ksi}$ } AISC Table J3.2 $f_v = \frac{120}{(8)(0.6)} = 25 \text{ ksi}$ $f_t = \frac{160}{(8)(0.6)} = 33.33 \text{ ksi}$ $\phi F_{mt} = 1.3 F_{mt} - \frac{F_{mt}}{\phi F_{mv}} f_v \leq F_{mt}$ (AISC Eq. J3-3a) $\phi F_{mt} = (1.3)(90) - \frac{90}{(0.75)(60)}(25)$ $= 67 \text{ ksi} < 90 \text{ ksi} \quad \underline{\text{ok}}$ $\phi F_{mt} = (0.75)(67) = 50.25 \text{ ksi}$ $> f_t = 33.33 \text{ ksi}$ <div style="border: 1px solid black; padding: 5px; display: inline-block;">Connection is ok</div>	$P_a = 125 \text{ k}$ $V_a = \left(\frac{3}{5}\right)(125) = 75 \text{ k}$ $H_a = \left(\frac{4}{5}\right)(125) = 100 \text{ k}$ $F_{mt} = 90 \text{ ksi}$ $F_{mv} = 60 \text{ ksi}$ } AISC Table J3.2 $f_v = \frac{75}{(8)(0.6)} = 15.62 \text{ ksi}$ $f_t = \frac{100}{(8)(0.6)} = 20.83 \text{ ksi}$ $\phi F_{mt} = 1.3 F_{mt} - \frac{\Omega F_{mt}}{F_{mv}} f_v \leq F_{mt}$ (AISC Eq. J3-3b) $\phi F_{mt} = (1.3)(90) - \frac{(2)(90)}{60}(15.62)$ $= 70.14 \text{ ksi} < 90 \text{ ksi} \quad \underline{\text{ok}}$ $\frac{\phi F_{mt}}{\Omega} = \frac{70.14}{2.00} = 35.07 \text{ ksi}$ $> f_t = 20.83 \text{ ksi}$ <div style="border: 1px solid black; padding: 5px; display: inline-block;">Connection is ok</div>

✓ g CMC

EXCLUSIVE: Just in Edutruth only

PROB# 13-14

R_m for 1 A325 $\frac{7}{8}$ bolt in a slip critical connection

$$R_m = \mu D_u h_{sc} T_b N_s = (0.35)(1.13)(1.00)(39)(1) = 15.42 \text{ k}$$

LRFD $\phi = 0.85$	ASD $\Omega = 1.76$
$V_u = \left(\frac{3}{5}\right)(200) = 120 \text{ k}$ $T_u = \left(\frac{4}{5}\right)(200) = 160 \text{ k}$ $\phi R_m = (0.85)(15.42) = 13.11 \text{ k/bolt}$ Reduction factor due to tensile load $k_s = 1 - \frac{T_u}{D_u T_b N_b} \quad (\text{AISC Eq. J3-5a})$ $k_s = 1 - \frac{160}{(1.13)(39)(8)} = 0.546$ Reduced $\phi R_m / \text{bolt} = (0.546)(13.11)$ $= 7.16 \text{ k/bolt}$ Design slip resistance for 8 bolts $= (8)(7.16) = 57.28 \text{ k}$ $< 120 \text{ k} \quad \underline{\text{N.G.}}$ <div style="border: 1px solid black; padding: 5px; width: fit-content;">Connection is unsatisfactory</div>	$V_a = \left(\frac{3}{5}\right)(125) = 75 \text{ k}$ $T_a = \left(\frac{4}{5}\right)(125) = 100 \text{ k}$ $\frac{R_m}{\Omega} = \frac{15.42}{1.76} = 8.76 \text{ k/bolt}$ Reduction factor due to tensile load $k_s = 1 - \frac{1.5 T_a}{D_u T_b N_b} \quad (\text{AISC Eq. J3-5b})$ $k_s = 1 - \frac{(1.5)(100)}{(1.13)(39)(8)} = 0.575$ Reduced $\frac{R_m}{\Omega} / \text{bolt} = (0.575)(8.76)$ $= 5.037 \text{ k/bolt}$ Allowable slip resistance for 8 bolts $= (8)(5.037) = 40.3 \text{ k}$ $< 75 \text{ k} \quad \underline{\text{N.G.}}$ <div style="border: 1px solid black; padding: 5px; width: fit-content;">Connection is unsatisfactory</div>

✓ JCM

EXCLUSIVE: Just in Edutruth only

PROB # 13-15

LRFD $\phi = 0.75$	ASD $\Omega = 2.00$
$V = \frac{1}{\sqrt{5}} P_u = 0.447 P_u$ $H = \frac{2}{\sqrt{5}} P_u = 0.894 P_u$ $F_{mt} = 113 \text{ ksi}$ $F_{mv} = 75 \text{ ksi}$	$V = \frac{1}{\sqrt{5}} P_a = 0.447 P_a$ $H = \frac{2}{\sqrt{5}} P_a = 0.894 P_a$ $F_{mt} = 113 \text{ ksi}$ $F_{mv} = 75 \text{ ksi}$
$\left. \begin{array}{l} F_{mt} = 113 \text{ ksi} \\ F_{mv} = 75 \text{ ksi} \end{array} \right\} \text{ AISC Table J3.2}$	$\left. \begin{array}{l} F_{mt} = 113 \text{ ksi} \\ F_{mv} = 75 \text{ ksi} \end{array} \right\} \text{ AISC Table J3.2}$
$f_v = \frac{0.447 P_u}{(10)(0.44)} = 0.102 P_u$ $f_t = \frac{0.894 P_u}{(10)(0.44)} = 0.203 P_u$	$f_v = \frac{0.447 P_a}{(10)(0.44)} = 0.102 P_a$ $f_t = \frac{0.894 P_a}{(10)(0.44)} = 0.203 P_a$
$\phi F_{mt} \geq 1.3 F_{mt} - \frac{F_{mt}}{\phi F_{mv}} = F_{mt}$ (AISC Eq. J3-3a)	$F_{mt} \geq 1.3 F_{mt} - \frac{F_{mt}}{F_{mv}} = F_{mt}$ (AISC Eq. J3-3b)
$(1.3)(113) - \frac{113}{(0.75)(75)} (0.102 P_u) = 113$ $146.9 - 0.2049 P_u = 113$	$(1.3)(113) - \frac{(2.00)(113)}{75} (0.102 P_a) = 113$ $146.9 - 0.307 P_a = 113$
$P_u = 165.4 \text{ k}$	$P_a = 110.4 \text{ k}$

VGC MC

EXCLUSIVE: Just in Edutruth only

PROB# 13-16

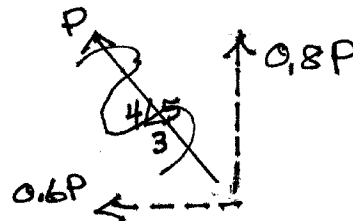
LRFD $\phi = 0.75$	ASD $\Omega = 2.00$
$V = \frac{1}{\sqrt{5}} P_u = 0.447 P_u$ $H = \frac{2}{\sqrt{5}} P_u = 0.894 P_u$ $F_{mt} = 90 \text{ ksi}$ $F_{mv} = 60 \text{ ksi}$	$V = \frac{1}{\sqrt{5}} P_a = 0.447 P_a$ $H = \frac{2}{\sqrt{5}} P_a = 0.894 P_a$ $F_{mt} = 90 \text{ ksi}$ $F_{mv} = 60 \text{ ksi}$
$F_{mt} = 90 \text{ ksi}$ $F_{mv} = 60 \text{ ksi}$	$F_{mt} = 90 \text{ ksi}$ $F_{mv} = 60 \text{ ksi}$
$f_v = \frac{0.447 P_u}{(10)(0.44)} = 0.102 P_u$ $f_t = \frac{0.894 P_u}{(10)(0.44)} = 0.203 P_u$	$f_v = \frac{0.447 P_a}{(10)(0.44)} = 0.102 P_a$ $f_t = \frac{0.894 P_a}{(10)(0.44)} = 0.203 P_a$
$F'_{mt} = 1.3 F_{mt} - \frac{F_{mt}}{\phi F_{mv}} f_v \leq F_{mt}$ (AISC Eq. J3-3a)	$F'_{mt} = 1.3 F_{mt} - \frac{\Omega F_{mt}}{\phi F_{mv}} f_v \leq F_{mt}$ (AISC Eq. J3-3b)
$F'_{mt} = (1.3)(90) - \frac{90}{(0.75)(60)} (0.102 P_u) \leq 90$ $117 - 0.204 P_u \leq 90$	$F'_{mt} = (1.3)(90) - \frac{(2)(90)}{60} (0.102 P_a) \leq 90$ $117 - 0.306 P_a \leq 90$
$P_u = 132.4 \text{ k}$	$P_a = 88.2 \text{ k}$

V & C M S

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EXCLUSIVE: Just in Edutruth only

PROB #13-17



Design of bolts in angles

Bolts in DS & Bearing on $\frac{7}{8}$ in.

DS strength per bolt

$$\phi R_n = (2)(0.44)(60) = 52.8 \text{ k} \leftarrow$$

Bearing strength per bolt

$$L_c = 1.00 \text{ in. given}$$

$$\phi R_n = 1.2 L_c \leq \phi R_n \leq 2.4 d \leq F_u$$

$$\phi R_n = (1.2)(1.0)(\frac{7}{8})(65) = 68.25 \text{ k} < (2.4)(\frac{3}{4})(\frac{7}{8})(65) = 102.4 \text{ k}$$

LRFD $\phi = 0.75$	ASD $\Omega = 2.00$
$P_u = 244 \text{ k}$ $\phi R_n = (0.75)(52.8) = 39.6 \text{ k}$ $\text{No. of bolts reqd} = \frac{244}{39.6} = 6.16$ <div style="border: 1px solid black; padding: 2px; display: inline-block;">USE 7 BOLTS</div>	$P_a = 170 \text{ k}$ $\frac{\phi R_n}{\Omega} = \frac{52.8}{2.00} = 26.4 \text{ k}$ $\text{No. reqd} = \frac{170}{26.4} = 6.44$ <div style="border: 1px solid black; padding: 2px; display: inline-block;">USE 7 Bolts</div>

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EXCLUSIVE: Just in Edutruth only

PROB #13-17 CONTD.

LRFD	ASD
$P_{uH} = (0.8)(244) = 195.2 \text{ k}$ $P_{uV} = (0.6)(244) = 146.4 \text{ k}$ $\text{Tension per bolt} = \frac{195.2}{N_b}$ $\text{Shear per bolt} = \frac{146.4}{N_b}$ $f_v = \frac{146.4}{(N_b)(0.44)} = \frac{332.7}{N_b}$ $\text{Checking combined tension and shear}$ $F'_{mt} = (1.3)(90) - \frac{90}{(0.75)(60)} \left(\frac{332.7}{N_b} \right)$ $\leq F_{mt}$ $F'_{mt} = 117 - \frac{665.4}{N_b}$ $r_m = F'_{mt} A_b = \left(117 - \frac{665.4}{N_b} \right) (0.44)$ $= 51.48 - \frac{292.77}{N_b}$ $\phi r_m = (0.75) \left(51.48 - \frac{292.77}{N_b} \right)$ $= 38.61 - \frac{219.58}{N_b}$ $38.61 - \frac{219.58}{N_b} = \frac{195.2}{N_b}$ $N_b = 10.74 \text{ bolts say } 11$	$P_{aH} = (0.8)(170) = 136 \text{ k}$ $P_{aV} = (0.6)(170) = 102 \text{ k}$ $\text{Tension per bolt} = \frac{136}{N_b}$ $\text{Shear per bolt} = \frac{102}{N_b}$ $f_v = \frac{102}{N_b(0.44)} = \frac{231.8}{N_b}$ $\text{Checking combined shear \& tension}$ $F'_{mt} = (1.3)(90) - \frac{(2.00)(90)}{60} \left(\frac{231.8}{N_b} \right)$ $F'_{mt} = 117 - \frac{695.4}{N_b} \leq 90$ $r_m = F'_{mt} A_b = \left(117 - \frac{695.4}{N_b} \right) (0.44)$ $r_m = 51.48 - \frac{305.98}{N_b}$ $\frac{r_m}{r} = \frac{r_m}{2.00} = 25.74 - \frac{152.99}{N_b}$ $25.74 - \frac{152.99}{N_b} = \frac{136}{N_b}$ $25.74 N_b - 204 =$ $N_b = 11.23 \text{ bolts say } 12$

WJCM

EXCLUSIVE: Just in Edutruth only

PROB# 13-18

Rivets in SS & Bearing on $\frac{1}{2}$ in.

L RFD	ASD
<p><u>Tensile yielding of PLS</u></p> $\phi_t P_m = \phi_t F_y A_g$ $= (0.9)(36)(\frac{1}{2} \times 14) = 226.8 \text{ k}$ <p><u>Tensile rupture</u></p> <p>Noting $u = 1.0$</p> $A_n = 7.00 - (4)(\frac{3}{4} + \frac{1}{8})(\frac{1}{2}) = 5.25 \text{ in.}^2$ $A_e = (1.00)(5.25) = 5.25 \text{ in.}^2$ $P_m = (58)(5.25) = 304.5 \text{ k}$ $\phi_t P_m = (0.75)(304.5) = 228.4 \text{ k}$ <p><u>SS Strength of rivets</u></p> $R_m = (12)(0.44)(25) = 132 \text{ k}$ $\phi R_m = (0.75)(132) = 99 \text{ k}$ <p><u>Bearing strength of rivets</u></p> $L_c = \text{lesser of } 1.50 - \frac{1}{2}(\frac{3}{4} + \frac{1}{8}) = 1.06 \text{ in.}$ <p>or $3.00 - (\frac{3}{4} + \frac{1}{8}) = 2.125 \text{ in.}$</p> $R_m = 1.2 L_c F_u (N_o \text{ of rivets})$ $\leq 2.4 d t F_u (N_o \text{ of rivets})$ $(1.2)(1.06)(\frac{1}{2})(58)(12) = 442.7 \text{ k}$ $< (2.4)(\frac{3}{4})(\frac{1}{2})(58)(12) = 626.4 \text{ k}$ $\phi R_m = (0.75)(442.7) = 332 \text{ k}$	<p><u>Tensile yielding of PLS</u></p> $\frac{P_m}{\Omega_t} = \frac{F_y A_g}{\Omega_t} = \frac{(36)(\frac{1}{2} \times 14)}{1.67}$ $= 150.9 \text{ k}$ <p><u>Tensile rupture</u></p> <p>Noting $u = 1.0$</p> $A_n = 7.00 - (4)(\frac{3}{4} + \frac{1}{8})(\frac{1}{2}) = 5.25 \text{ in.}^2$ $A_e = (1.00)(5.25) = 5.25 \text{ in.}^2$ $P_m = F_u A_e = (58)(5.25) = 304.5 \text{ k}$ $\frac{P_m}{\Omega_t} = \frac{304.5}{2.00} = 152.2 \text{ k} \leftarrow$ <p><u>SS Strength of rivets</u></p> $R_m = (12)(0.44)(25) = 132 \text{ k}$ $\frac{R_m}{\Omega} = \frac{132}{2.00} = 66 \text{ k}$ <p><u>Bearing strength of rivets</u></p> $L_c = \text{lesser of } 1.50 - \frac{1}{2}(\frac{3}{4} + \frac{1}{8}) = 1.06 \text{ in.}$ <p>or $3.00 - (\frac{3}{4} + \frac{1}{8}) = 2.125 \text{ in.}$</p> $R_m = (1.2)(L_c F_u)(N_o \text{ of rivets})$ $\leq 2.4 d t F_u (N_o \text{ of rivets})$ $(1.2)(1.06)(\frac{1}{2})(58)(12) = 442.7 \text{ k}$ $< (2.4)(\frac{3}{4})(\frac{1}{2})(58)(12) = 626.4 \text{ k}$ $\frac{R_m}{\Omega} = \frac{442.7}{2.00} = 221.3 \text{ k}$

ANSWRS

99 k L RFD

66 k ASD

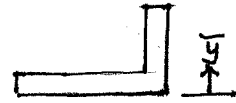
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✓ 9/11/18

EXCLUSIVE: Just in Edutruth only

PROB #13-19

Using on L 5X3X $\frac{5}{16}$ ($A=2.40 \text{ in}^2$, $\bar{y}=0.673 \text{ in.}$)



LRFD	ASD
<p>For tensile yielding</p> $P_m = F_y A_g = (36)(2.40) = 86.4 \text{ k}$ $\phi_t P_m = (0.9)(86.4) = 77.8 \text{ k}$ <p>For tensile rupture</p> $u \text{ given} = 0.9$ $A_e = u A_m = (0.9) \left[2.40 - \left(\frac{5}{16} \right) \left(\frac{7}{8} + \frac{1}{8} \right) \right]$ $= 1.881 \text{ in}^2$ $P_m = F_u A_e = (58)(1.881) = 109 \text{ k}$ $\phi_t P_m = (0.75)(109) = 81.8 \text{ k}$ <p>Bolts in SS & Bearing on $\frac{5}{16} \text{ in.}$</p> <p>Shear</p> $R_m = (5)(0.6)(25) = 75 \text{ k}$ $\phi R_m = (0.75)(75) = 56.2 \text{ k} \leftarrow$ <p>Bearing</p> $L_c = 2 - \frac{1}{2} \left(\frac{7}{8} + \frac{1}{8} \right) = 1.50 \text{ in.}$ <p>or $3 - \left(\frac{7}{8} + \frac{1}{8} \right) = 2.00 \text{ in.}$</p> $R_m = (5)(1.2)L_c \leq (5)(2.4)(F_u)$ $= (5)(1.2)(1.5) \left(\frac{5}{16} \right) (58) = 163 \text{ k}$ $< (5)(2.4) \left(\frac{5}{16} \right) (58) = 190.3 \text{ k}$ $\phi R_m = (0.75)(163.1) = 122.3 \text{ k}$	<p>For tensile yielding</p> $P_m = F_y A_g = (36)(2.40) = 86.4 \text{ k}$ $\frac{P_m}{\Omega} = \frac{86.4}{1.67} = 51.7 \text{ k}$ <p>For tensile rupture</p> $u \text{ given} = 0.9$ $A_e = u A_m = (0.9) \left[2.40 - \left(\frac{5}{16} \right) \left(\frac{7}{8} + \frac{1}{8} \right) \right]$ $= 1.881 \text{ in}^2$ $P_m = F_u A_e = (58)(1.881) = 109 \text{ k}$ $\frac{P_m}{\Omega} = \frac{109}{2.00} = 54.5 \text{ k}$ <p>Bolts in SS & Bearing on $\frac{5}{16} \text{ in.}$</p> <p>Shear</p> $R_m = (5)(0.6)(25) = 75 \text{ k}$ $\frac{R_m}{\Omega} = \frac{75}{2.00} = 37.5 \text{ k} \leftarrow$ <p>Bearing</p> $L_c = 2 - \frac{1}{2} \left(\frac{7}{8} + \frac{1}{8} \right) = 1.50 \text{ in.}$ <p>or $3 - \left(\frac{7}{8} + \frac{1}{8} \right) = 2.00 \text{ in.}$</p> $R_m = (5)(1.2)L_c \leq (5)(2.4)(F_u)$ $= (5)(1.2)(1.5) \left(\frac{5}{16} \right) (58) = 163 \text{ k}$ $(5)(2.4) \left(\frac{5}{16} \right) (58) = 190.3 \text{ k}$ $\frac{R_m}{\Omega} = \frac{163.1}{2.00} = 81.5 \text{ k}$

ANSWERS.

56.2 k LRFD

37.5 k ASD

✓ g CMC

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EXCLUSIVE: Just in Edutruth only

PROB # 13-20

LRFD	ASD
$P_u = 216 \text{ k}$	$P_a = 150 \text{ k}$

Rivets in SS & Bearing on $\frac{1}{2}$ in.
Shear
 $R_m = (0.44)(25) = 11 \text{ k}$

LRFD $\phi = 0.75$	ASD $\Omega = 2.00$
$\phi R_m = (0.75)(11) = 8.25 \text{ k each}$	$\frac{R_m}{\Omega} = \frac{11}{2.00} = 5.50 \text{ k each}$

Bearing

$L_c = \text{lesser of } 2 - (\frac{1}{2})(0.75 + \frac{1}{8}) = 1.56 \text{ in. or } 4 - (0.75 + \frac{1}{8}) = 3.125 \text{ in.}$

$$R_m = 1.2 L_c t F_u \leq 2.4 d t F_u$$

$$R_m = (1.2)(1.56)(\frac{1}{2})(58) = 54.3 \text{ k} > (2.4)(\frac{3}{4})(\frac{1}{2})(58) = 52.2 \text{ k}$$

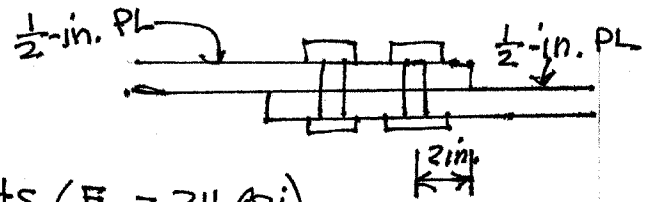
LRFD $\phi = 0.75$	ASD $\Omega = 2.00$
$\phi R_m = (0.75)(52.2) = 39.1 \text{ k each}$	$\frac{R_m}{\Omega} = \frac{52.2}{2.00} = 26.1 \text{ k each}$
No. of rivets reqd. = $\frac{216}{8.25}$ $= 26.2$ Say 27	No. of rivets reqd. = $\frac{150}{5.50}$ $= 27.27$ Say 28

✓ $\phi < m_c$

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EXCLUSIVE: Just in Edutruth only

PROB # 13-21



Using $\frac{3}{4}$ -in. A 307 bolts ($F_v = 24 \text{ ksi}$)

Bolts in SS & Bearing on $\frac{1}{2}$ in.

LRFD $P_u = 216 \text{ k}$	ASD $P_a = 150 \text{ k}$
SS strength of 1 bolt	SS strength of 1 bolt
$\phi_m = (0.44)(24) = 10.56 \text{ k}$	$\phi_m = (0.44)(24) = 10.56 \text{ k}$
Bearing strength of 1 bolt	Bearing strength of 1 bolt
$L_c = 2 - \frac{3/4 + 1/8}{2} = 1.56 \text{ in.}$	$L_c = 2 - \frac{3/4 + 1/8}{2} = 1.56 \text{ in.}$
$\phi_m = 1.2 L_c \leq F_u \leq 2.4 d \leq F_u$	$\phi_m = 1.2 L_c \leq F_u \leq 2.4 d \leq F_u$
$= (1.2)(1.56)(\frac{1}{2})(58)$	$= (1.2)(1.56)(\frac{1}{2})(58)$
$= 54.29 \text{ k}$	$= 54.29 \text{ k}$
$> (2.4)(\frac{3}{4})(\frac{1}{2})(58) = 52.2 \text{ k}$	$> (2.4)(\frac{3}{4})(\frac{1}{2})(58) = 52.2 \text{ k}$
$\phi_m = (0.75)(10.56) = 7.92 \text{ k}$	$\frac{\phi_m}{2} = \frac{10.56}{2.00} = 5.28 \text{ k}$
No of bolts required	No of bolts reqd
$= \frac{216}{7.92} = 27.27 \text{ bolts}$	$= \frac{150}{5.28} = 28.41 \text{ bolts}$

Answers \rightarrow **USE 28 bolts**

\rightarrow **USE 29 or 30 bolts**

✓ gcm

EXCLUSIVE: Just in Edutruth only

PROB # 13-22

Rivet in DS and Bearing on $\frac{3}{4}$ in.

LRFD	ASD
$P_u = (1.2)(60) + (1.6)(80) = 200 \text{ k}$	$P_a = 60 + 80 = 140 \text{ k}$

$$\begin{aligned} \phi R_n &= \text{DS strength of 1 rivet} \\ &= (2)(0.785)(25.0) = 39.25 \text{ k} \end{aligned}$$

LRFD $\phi = 0.75$	ASD $\Omega = 2.00$
$\phi R_n = (0.75)(39.25) = 29.44 \text{ k}$	$\frac{R_n}{\Omega} = \frac{39.25}{2.00} = 19.62 \text{ k} \leftarrow$

R_n = Bearing strength of 1 rivet

$$L_c = 1.5 - \left(\frac{1}{2}\right)\left(1 + \frac{1}{8}\right) = 0.9375 \text{ in.}$$

$$R_n = 1.2 L_c \leq F_u \leq 2.4 d \leq F_u$$

$$= (1.2)(0.9375)\left(\frac{3}{4}\right)(58) = \underline{48.94 \text{ k}} < (2.4)(1)\left(\frac{3}{4}\right)(58) = 104.4 \text{ k}$$

LRFD $\phi = 0.75$	ASD $\Omega = 2.00$
$\phi R_n = (0.75)(48.94) = 36.70 \text{ k}$	$\frac{R_n}{\Omega} = \frac{48.94}{2.00} = 24.47 \text{ k}$
No of rivets reqd. $= \frac{200}{29.44} = 6.79$	No of rivets reqd. $= \frac{140}{19.62} = 7.14$

Answers.

Use 7 rivets
LRFD

Use 8 rivets
ASD

✓ gcm

EXCLUSIVE: Just in Edutruth only

PROB # 13-23

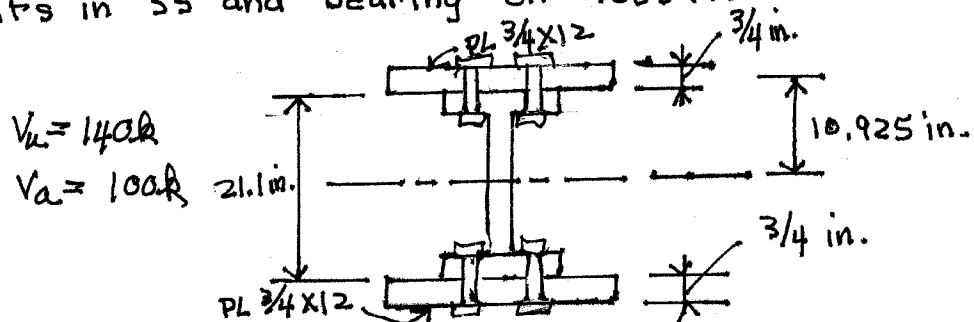
LRFD	ASD
$P_u = 652 \text{ k}$ Assume rivets in DS (not multiple shear) & bear. on 2.5 in.	$P_a = 490 \text{ k}$ Assume rivets in DS (not multiple shear) & bear. on 2.5 in.
<u>Shear strength</u> $R_n = (2)(0.6)(25) = 30 \text{ k}$ $\phi R_n = (0.75)(30) = 22.5 \text{ k each}$	<u>Shear strength</u> $R_n = (2)(0.6)(25) = 30 \text{ k}$ $\frac{R_n}{\Omega} = \frac{30}{2.00} = 15 \text{ k each}$
<u>Bearing strength</u> $L_c = 1.5 - \left(\frac{1}{2}\right)\left(\frac{7}{8} + \frac{1}{8}\right) = 1.00 \text{ in.}$ or $3 - \left(\frac{7}{8} + \frac{1}{8}\right) = 2.00 \text{ in.}$ $R_n = 1.2 L_c t F_u \leq 2.4 d t F_u$ $= (1.2)(1.0)(2.5)(58) = 174 \text{ k}$ $< (2.4)\left(\frac{7}{8}\right)(2.5)(58) = 304.5 \text{ k}$ $\phi R_n = (0.75)(174) = 130.5 \text{ k each}$ No. of rivets reqd. = $\frac{652}{22.5}$ $= 28.98 \text{ Say } 29 \text{ or } 30$	<u>Bearing strength</u> $L_c = 1.5 - \frac{1}{2}\left(\frac{7}{8} + \frac{1}{8}\right) = 1.00 \text{ in.}$ or $3 - \left(\frac{7}{8} + \frac{1}{8}\right) = 2.00 \text{ in.}$ $R_n = 1.2 L_c t F_u \leq 2.4 d t F_u$ $= (1.2)(1.0)(2.5)(58) = 174 \text{ k}$ $< (2.4)\left(\frac{7}{8}\right)(2.5)(58) = 304.5 \text{ k}$ $\frac{R_n}{\Omega} = \frac{174}{2.00} = 87 \text{ k each}$ No. of rivets reqd. = $\frac{490}{15}$ $= 32.7 \text{ Say } 33 \text{ or } 34$

✓ $\phi R_n =$

EXCLUSIVE: Just in Edutruth only

PROB #13-24

Bolts in SS and Bearing on 0.685 in.



$$V_u = 140 \text{ k}$$

$$V_a = 100 \text{ k}$$

using a W21x68 ($d=21.1 \text{ in.}$, $I_x=1480 \text{ in.}^4$, $t_f=0.685 \text{ in.}$)

$$I_x = 1480 + (2) \left(\frac{3}{4} \times 12 \right) (10.925)^2 = 3628 \text{ in.}^4$$

$$Q = \left(\frac{3}{4} \right) (12) (10.925) = 98.32 \text{ in.}^3$$

LRFD	ASD
$f_v = \frac{V_u}{I} = \frac{(140)(98.32)}{3628} = 3.794 \text{ k/in.}$	$f_v = \frac{V_a Q}{I} = \frac{(100)(98.32)}{3628} = 2.71 \text{ k/in.}$

SS strength of 1 bolt

$$\phi_m = (0.6)(24) = 14.4 \text{ k}$$

LRFD $\phi = 0.75$	ASD $\Omega = 2.00$
$\phi \phi_m = (0.75)(14.4) = 10.8 \text{ k}$	$\frac{\phi_m}{\Omega} = \frac{14.4}{2.00} = 7.2 \text{ k}$

Bearing strength of 1 bolt

$$\text{Assume } L_e = 2 - \frac{7/8 + 1/8}{2} = 1.50 \text{ in.}$$

$$\phi_m = 1.2 L_e \phi F_u \leq 2.4 d \phi F_u$$

$$= (1.2)(1.50)(0.685)(58) = 71.51 \text{ k} < (2.4) \left(\frac{7}{8} \right) (0.685)(58) = 83.43 \text{ k}$$

LRFD $\phi = 0.75$	ASD $\Omega = 2.00$
$\phi \phi_m = (0.75)(71.51) = 53.6 \text{ k}$	$\frac{\phi_m}{\Omega} = \frac{71.51}{2.00} = 35.8 \text{ k}$

ANSWER Spacing of bolts LRFD
 $= \frac{(2)(10.8)}{3.794} = 5.69 \text{ in.}$
 Say $5 \frac{1}{2} \text{ in.}$

Spacing of bolts ASD
 $= \frac{(2)(7.2)}{2.71} = 5.31$
 Say 5 in.

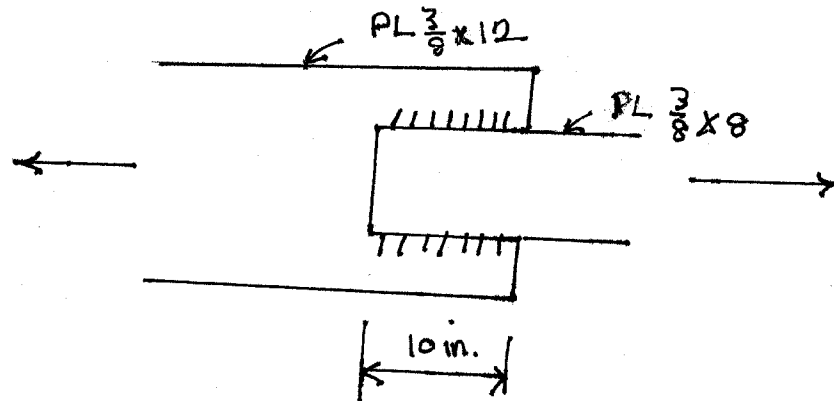
✓ JCM

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EXCLUSIVE: Just in Edutruth only

CHAPTER 14

PROB # 14-1



Nominal weld strength $R_n = F_w A_w = (0.60 \times 70) \left(\frac{1}{4} \times 0.707 \times 20 \right)$
 $= 148.5 \text{ k}$

Checking the length to weld size ratio

$\frac{L}{w} = \frac{10}{\frac{1}{4}} = 40 < 100 \therefore \text{No reduction in weld strength required}$

LAFD $\phi = 0.75$	ASD $\Omega = 2.00$
$\phi R_n = (0.75)(148.5) = 111.4 \text{ k}$	$\frac{R_n}{\Omega} = \frac{148.5}{2} = 74.2 \text{ k}$

Tensile yielding for $\frac{3}{8} \times 8 \text{ PL}$

$R_n = F_y A_g = (36) \left(\frac{3}{8} \times 8 \right) = 108 \text{ k}$

LAFD $\phi_t = 0.90$	ASD $\Omega_t = 1.67$
$\phi_t R_n = (0.90)(108) = 97.2 \text{ k}$	$\frac{R_n}{\Omega_t} = \frac{108}{1.67} = 64.7 \text{ k}$

Tensile rupture strength for $\frac{3}{8} \times 8 \text{ PL}$

$A_e = \left(\frac{3}{8} \times 8 \right) = 3 \text{ in}^2$

$R_n = F_u A_e = (58)(3) = 174 \text{ k}$

LAFD $\phi_t = 0.75$	ASD $\Omega_t = 2.00$
$\phi_t R_n = (0.75)(174) = 130.5 \text{ k}$	$\frac{R_n}{\Omega_t} = \frac{174}{2.00} = 87 \text{ k}$

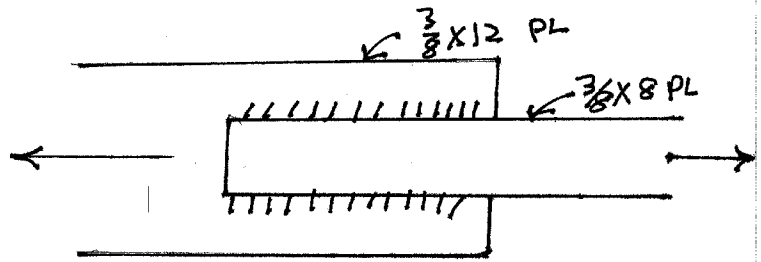
Ans. 97.2 k

64.7 k ✓ JCMC

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EXCLUSIVE: Just in Edutruth only

PROB # 14-2



$$\text{Nominal weld strength} = R_n = (0.60 \times 70) \left(\frac{1}{4} \times 0.707 \right) (32) = 237.5 \text{ k for one side}$$

Check the length to weld size ratio

$$\frac{L}{w} = \frac{32}{\frac{1}{4}} = 128 > 100$$

$$\therefore \phi = 1.2 - 0.002 \left(\frac{L}{w} \right)$$

$$= 1.2 - (0.002)(128) = 0.944$$

$$\phi R_n = (0.944)(237.6)(2) = 448.6 \text{ k}$$

LRFD $\phi = 0.75$	ASD $\Omega = 2.00$
$\phi R_n = (0.75)(448.6) = 336.4 \text{ k}$	$\frac{R_n}{\Omega} = \frac{448.6}{2.00} = 224.3 \text{ k}$

Referring to the solution of PROB # 14-1 we see that the strengths of the plates for tensile yielding and tensile rupture are given. The tensile yielding value controls and our final answers are

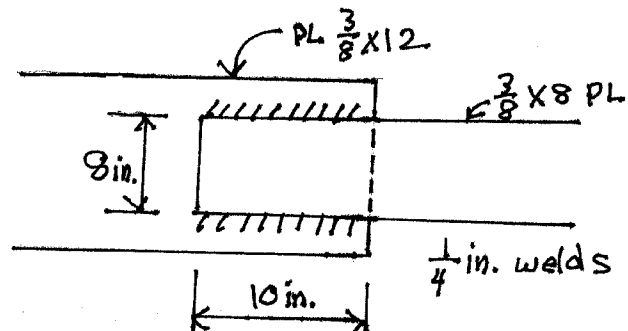
Ans. \rightarrow 97.2 k for LRFD and 64.7 k for ASD

UJMC

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EXCLUSIVE: Just in Edutruth only

PROB #14-3



Weld strength

Nominal strength of weld $R_n = F_w A_w$

$$= (0.60)(80)\left(\frac{1}{4} \times 0.707 \times 20\right) = 169.7 \text{ k}$$

Checking $\frac{L}{w} = \frac{10}{0.25} = 40 < 100 \text{ ok}$

LRFD $\phi_t = 0.75$	ASD $\Omega_t = 2.00$
$\phi_t R_n = (0.75)(169.7) = 127.3 \text{ k}$	$\frac{R_n}{\Omega_t} = \frac{169.7}{1.67} = 84.8 \text{ k}$

Tensile yielding for $\frac{3}{8} \times 8 \text{ PL}$

$$R_n = F_y A_g = (65)\left(\frac{3}{8} \times 8\right) = 195 \text{ k}$$

LRFD $\phi_t = 0.90$	ASD $\Omega_t = 1.67$
$\phi_t R_n = (0.90)(195) = 175.5 \text{ k}$	$\frac{R_n}{\Omega_t} = \frac{195}{1.67} = 116.8 \text{ k}$

Tensile rupture of $\frac{3}{8} \times 8 \text{ PL}$

$$A_e = \left(\frac{3}{8}\right)(8) = 3.00 \text{ in.}$$

$$R_n = F_u A_e = (80)(3.00) = 240 \text{ k}$$

LRFD $\phi_t = 0.75$	ASD $\Omega_t = 2.00$
$\phi_t R_n = (0.75)(240) = 180 \text{ k}$	$\frac{R_n}{\Omega_t} = \frac{240}{2.00} = 120 \text{ k}$

Ansr.

127.3 k

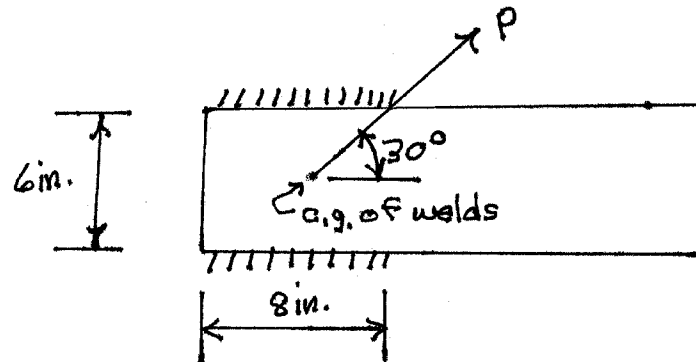
84.8 k

✓ 9 cm

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EXCLUSIVE: Just in Edutruth only

PROB # 14-4



Load applied at 30° angle with longitudinal axis of weld

$$\begin{aligned}
 R_m &= 0.60 F_{EXX} (1.0 + 0.50 \sin^{1.5} \theta) (A_w) \\
 &= (0.60)(70)(1.0 + 0.50 \sin^{1.5} 30^\circ) (2 \times 8 \times 0.707 \times \frac{5}{16}) \\
 &= 174.7 \text{ k}
 \end{aligned}$$

LRFD $\phi = 0.75$	ASD $\Omega = 2.00$
$\phi R_m = (0.75)(174.7) = 131 \text{ k}$	$\frac{R_m}{\Omega} = \frac{174.7}{2.00} = 87.3 \text{ k}$

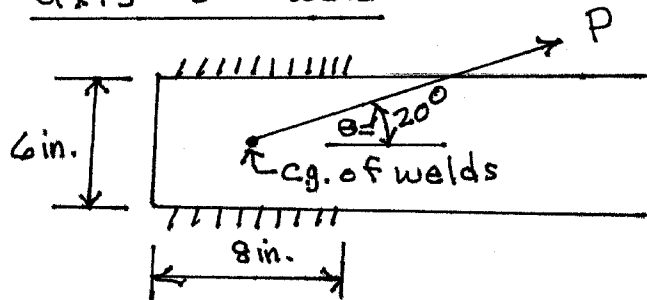
✓ 6M

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EXCLUSIVE: Just in Edutruth only

PROB# 14-5

(a) Load applied @ a 20° angle with longitudinal axis of weld



$$R_m = 0.60 F_{EXX} (1.0 + 0.50 \sin^{1.5} \theta) (A_w) \\ = (0.60)(70)(1.0 + 0.50 \sin^{1.5} 20^\circ) \left(\frac{1}{4} \times 0.707 \times 16 \right) = 130.7 k$$

LRFD $\phi = 0.75$	ASD $\Omega = 2.00$
$\phi R_m = (0.75)(130.7) = 98 k$	$\frac{R_m}{\Omega} = \frac{130.7}{2.00} = 65.3 k$

(b) Load applied with $\theta = 10^\circ$ for the figure shown above

$$R_m = (0.60)(70)(1.0 + 0.50 \sin^{1.5} 10^\circ) \left(\frac{1}{4} \times 0.707 \times 16 \right) \\ = 123.1 k$$

LRFD $\phi = 0.75$	ASD $\Omega = 2.00$
$\phi R_m = (0.75)(123.1) = 92.3 k$	$\frac{R_m}{\Omega} = \frac{123.1}{2.00} = 61.5 k$

✓ gmc

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EXCLUSIVE: Just in Edutruth only

PROB#14-6

LRFD	ASD
$P_u = (1.2)(40) + (1.6)(60) = 144 \text{ k}$	$P_a = 40 + 60 = 100 \text{ k}$

Max weld size = $\frac{1}{2} - \frac{1}{16} = \frac{7}{16} \text{ in.}$

Strength of $\frac{7}{16} \text{ in.}$ weld per inch = $F_w A_w$

$$= (0.60 \times 70) \left(\frac{7}{16} \times 0.707 \right) = 12.99 \text{ k/in.}$$

LRFD $\phi = 0.75$	ASD $\Omega = 2.00$
$\phi R_m / \text{in.} = (0.75)(12.99) = 9.74 \text{ k/in.}$	$\frac{R_m}{\Omega} \text{ per in.} = \frac{12.99}{2.00} = 6.50 \text{ k/in.}$
$2L = \frac{144}{9.74} = 14.78 \text{ in.}$	$2L = \frac{100}{6.50} = 15.38 \text{ in.}$
$L = 7.39$	$L = 7.69 \text{ in.}$
<u>USE $7\frac{1}{2} \text{ in.}$</u>	<u>USE 8 in. weld</u>
<u>weld each side</u>	<u>each side</u>

✓ JCM

EXCLUSIVE: Just in Edutruth only

PROB #14-7

LRFD	ASD
$P_u = (1.2)(40) + (1.6)(60) = 144 \text{ k}$	$P_a = 40 + 60 = 100 \text{ k}$

Nominal strength of $\frac{5}{16}$ in. weld per inch = $F_w A_w$
 $= (0.60)(70) \left(\frac{5}{16} \times 0.707 \right) = 9.28 \text{ k/in.}$

LRFD $\phi = 0.75$	ASD $\Omega = 2.00$
$\phi R_n \text{ per in.} = (0.75)(9.28) = 6.96 \text{ k/in.}$	$\frac{R_n}{\Omega} = \frac{9.28}{2.00} = 4.64 \text{ k/in.}$
$2L = \frac{144}{6.96} = 20.69 \text{ in.}$	$2L = \frac{100}{4.64} = 21.55 \text{ in.}$
$L = 10.34 \text{ in.}$	$L = 10.78 \text{ in.}$

Ans.

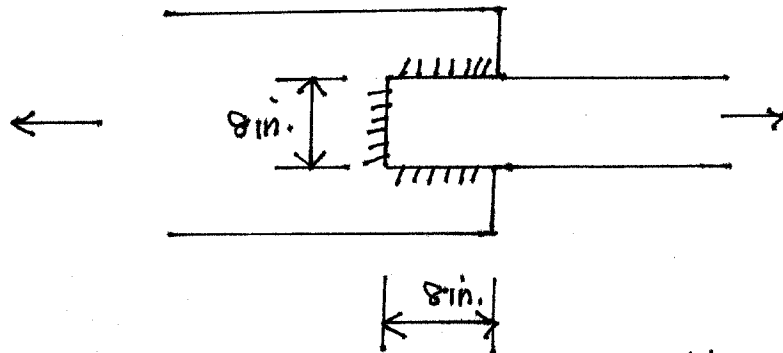
USE 10 $\frac{1}{2}$ in. long $\frac{5}{16}$ weld
each side

USE 11 in. long $\frac{5}{16}$ weld
each side

✓ JCM

EXCLUSIVE: Just in Edutruth only

PROB # 14-8



Nominal strength of end transverse weld

$$R_{we} = F_w A_w = (0.60 \times 80) \left(0.707 \times \frac{5}{16} \right) (2 \times 8) = 169.68 k$$

$$R_{wt} = F_w A_w = (0.60 \times 80) \left(0.707 \times \frac{5}{16} \right) (8) = 84.84 k$$

$$R_m = R_{we} + R_{wt} = 169.68 + 84.84 = 254.5 k$$

(AISC Eq. 2-9a)

$$R_m = 0.85 R_{we} + 1.5 R_{wt} \quad (\text{AISC Eq. 2-9b})$$

$$= (0.85)(169.68) + (1.5)(84.84) = 271.5 k \leftarrow$$

LAFD $\phi = 0.75$	ASD $\Omega = 2.00$
$\phi R_m = (0.75)(271.5) = 203.6 k$	$\frac{R_m}{\Omega} = \frac{271.5}{2.00} = 135.7 k$

Ans.

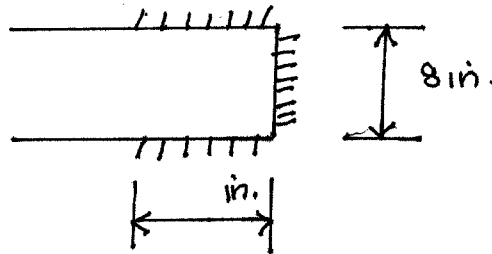
203.6 k

135.7 k

✓ gcm

EXCLUSIVE: Just in Edutruth only

PROB # 14-9



$$R_{we} = (0.60 \times 70)(0.707 \times \frac{1}{4})(2 \times 8) = 118.78 \text{ k}$$

$$R_{wt} = (0.60 \times 70)(0.707 \times \frac{1}{4})(8) = 59.39 \text{ k}$$

$$R_m = R_{we} + R_{wt} = 118.78 + 59.39 = 178.17 \text{ k (AISC Eq. J2-9a)}$$

$$R_m = 0.85 R_{we} + 1.5 R_{wt} = (0.85)(118.78) + (1.5)(59.39) = 190.05 \text{ k (AISC Eq. J2-9b)} \leftarrow$$

LRFD $\phi = 0.75$	ASD $\Omega = 2.00$
$\phi R_m = (0.75)(190.05) = 142.5 \text{ k}$	$\frac{R_m}{\Omega} = \frac{190.05}{2.00} = 95 \text{ k}$

Ans.

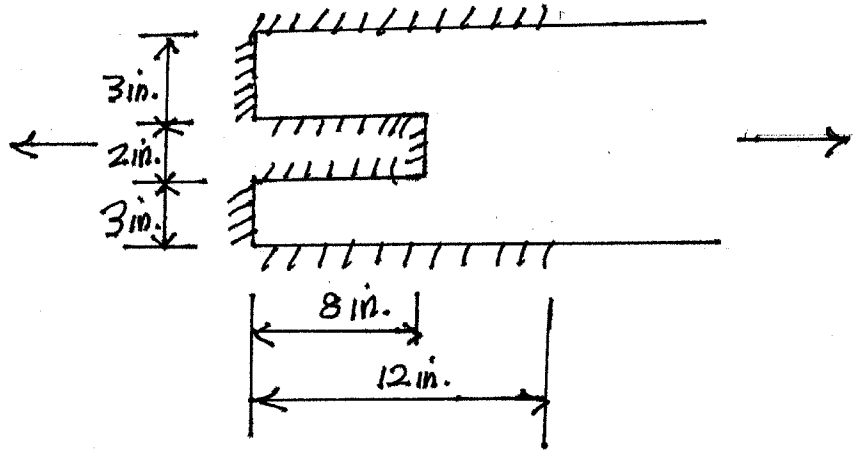
142.5 k

95 k

✓ JCLMS

EXCLUSIVE: Just in Edutruth only

PROB # 14-10



using $\frac{5}{16}$ -in. welds

$$R_{wL} = F_w A_w = (0.60 \times 70) \left(0.707 \times \frac{5}{16} \right) (12 + 8 + 8 + 12) = 371.175 \text{ k}$$

$$R_{wT} = F_w A_w = (0.60 \times 70) \left(0.707 \times \frac{5}{16} \right) (3 + 2 + 3) = 74.235 \text{ k}$$

$$R_m = R_{wL} + R_{wT} = 371.175 + 74.235 = 445.4 \text{ k} \leftarrow$$

$$R_m = 0.85 R_{wL} + 1.5 R_{wT} = (0.85)(371.175) + (1.5)(74.235) = 426.9 \text{ k}$$

LRFD $\phi = 0.75$	ASD $\Omega = 2.00$
$\phi R_m = (0.75)(445.4) = 334 \text{ k}$	$\frac{R_m}{\Omega} = \frac{445.4}{2.00} = 222.7 \text{ k}$

Ans. \rightarrow

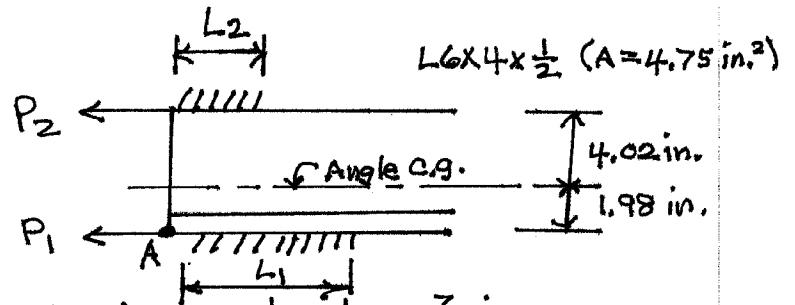
334 k

222.7 k

vgcm

EXCLUSIVE: Just in Edutruth only

PROB #14-11



$$\text{max weld size} = \frac{1}{2} - \frac{1}{16} = \frac{7}{16} \text{ in.}$$

$$\text{Effective throat } t = (0.707) \left(\frac{7}{16} \right) = 0.309 \text{ in.}$$

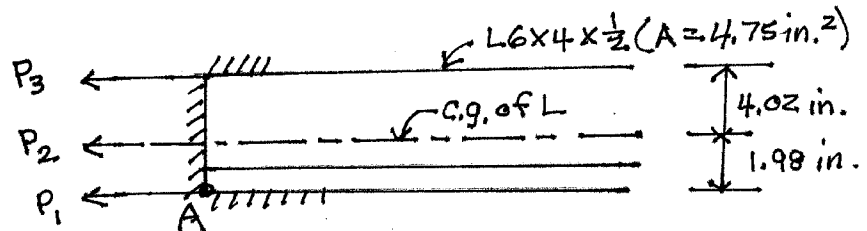
LRFD $\phi = 0.75$	ASD $\Omega = 2.00$
$P_u = (1.2)(70) + (1.6)(60) = 180 \text{ k}$ Design strength/in. of $\frac{7}{16}$ welds $= (0.75)(0.6 \times 70)(0.309)(1)$ $= 9.73 \text{ k/in.}$ weld length reqd. $= \frac{180}{9.73}$ $= 18.50 \text{ in.}$ Taking moments about A point on sketch $(180)(1.98) - 6P_2 = 0$ $P_2 = 59.4 \text{ k}$ $L_2 = \frac{59.4}{9.73} = 6.10 \text{ in. Say } 6 \text{ in.}$ $L_1 = 18.50 - 6.10 = 12.4 \text{ in.}$ <u>Say 12.5 in.</u>	$P_a = 70 + 60 = 130 \text{ k}$ Allowable strength of $\frac{7}{16}$ welds $= \frac{(0.6 \times 70)(0.309)(1)}{2.00} = 6.49 \text{ k/in.}$ Weld length reqd. $= \frac{130}{6.49} = 20.03 \text{ in.}$ Taking moments about point A on sketch $(130)(1.98) - 6P_2 = 0$ $P_2 = 42.9 \text{ k}$ $L_2 = \frac{42.9}{6.49} = 6.61 \text{ in.}$ <u>Say 7 in.</u> $L_1 = 20.03 - 6.61 = 13.42 \text{ in.}$ <u>Say 13 1/2 in.</u>

✓ JCM

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EXCLUSIVE: Just in Edutruth only

PROB # 14-12



$$\text{Max weld size} = \frac{1}{2} - \frac{1}{16} = \frac{7}{16} \text{ in.}$$

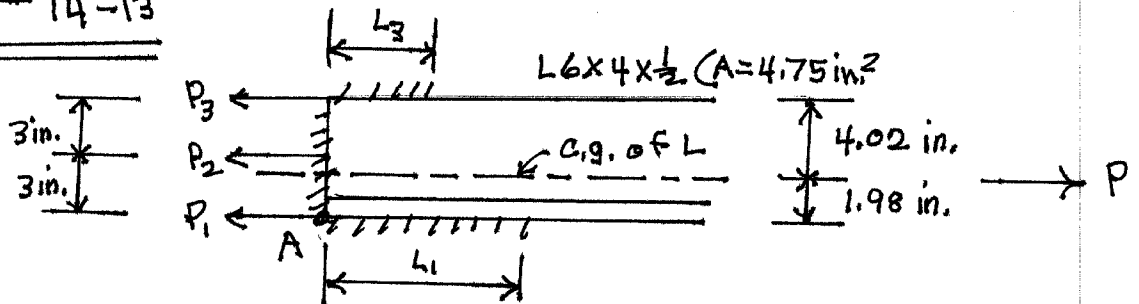
$$\text{Effective throat } t = (0.707) \left(\frac{7}{16} \right) = 0.309 \text{ in.}$$

LRFD $\phi = 0.75$	ASD $\Omega = 2.00$
$P_u = (1.2)(70) + (1.6)(60) = 180 \text{ k}$ Design strength / in. of $\frac{7}{16}$ in. welds $= (0.75)(0.60 \times 70)(0.309)(1) = 9.73 \text{ k/in.}$ Weld length reqd $= \frac{180}{9.73}$ $= 18.50 \text{ in.}$ $P_2 = (6)(9.73) = 58.38 \text{ k}$ Taking moments about pt. A $-(58.38)(3) + 6P_3 + (180)(1.98) = 0$ $P_3 = 30.21 \text{ k}$ $L_3 = \frac{30.21}{9.73} = 3.10 \text{ in.}$ <div style="border: 1px solid black; padding: 2px; display: inline-block;">Say $3\frac{1}{2}$ in.</div> $L_1 = \frac{180 - P_2 - P_3}{9.73}$ $= \frac{180 - 58.38 - 30.21}{9.73} = 9.39 \text{ in.}$ <div style="border: 1px solid black; padding: 2px; display: inline-block;">Say $9\frac{1}{2}$ in.</div>	$P_a = 70 + 60 = 130 \text{ k}$ Allow. strength of $\frac{7}{16}$ in. welds $= \frac{(0.60)(70)(0.309)(1)}{2.00} = 6.49 \text{ k/in.}$ Weld length reqd $= \frac{130}{6.49}$ $= 20.03 \text{ in.}$ $P_2 = (6)(6.49) = 38.94 \text{ k}$ Taking moments about pt. A $-(38.94)(3) - 6P_3 + (130)(1.98) = 0$ $P_3 = 23.43 \text{ k}$ $L_3 = \frac{23.43}{6.49} = 3.61 \text{ in.}$ <div style="border: 1px solid black; padding: 2px; display: inline-block;">Say 4 in.</div> $L_1 = \frac{130 - 38.94 - 23.43}{6.49}$ $= 10.42 \text{ in.}$ <div style="border: 1px solid black; padding: 2px; display: inline-block;">Say $10\frac{1}{2}$ in.</div>

✓ JCM

EXCLUSIVE: Just in Edutruth only

PROB # 14-13



$$\text{Max weld size} = \frac{1}{2} - \frac{1}{16} = \frac{7}{16} \text{ in.}$$

$$\text{Effective throat} = (0.707) \left(\frac{7}{16} \right) = 0.309 \text{ in.}$$

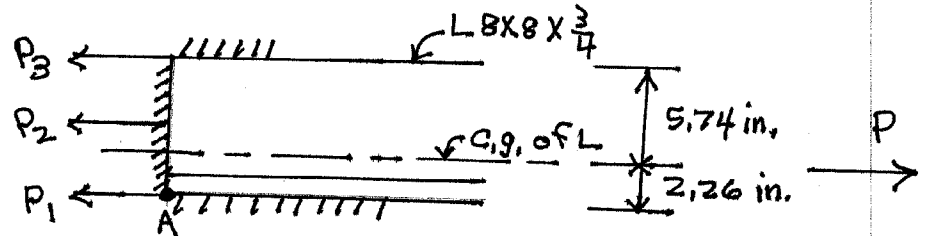
LRFD $\phi = 0.75$	ASD $\Omega = 2.00$
$P_u = (1.2)(70) + (1.6)(60) = 180 \text{ k}$ Design strength/in. of $\frac{7}{16}$ in. welds $= (0.75)(0.60 \times 80)(0.309) = 11.12 \text{ k/in.}$ Weld length reqd $= \frac{180}{11.12} = 16.19 \text{ in.}$ $P_2 = (6)(11.12) = 66.72$ Taking moments about point A on sketch $-(66.72)(3) - 6P_3 + (180)(1.98) = 0$ $P_3 = 26.04 \text{ k}$ $L_3 = \frac{26.04}{11.12} = 2.34 \text{ in.}$ Say $2\frac{1}{2} \text{ in.}$ $L_1 = \frac{180 - P_2 - P_3}{11.12}$ $= \frac{180 - 66.72 - 26.04}{11.12}$ $= 7.85 \text{ in.}$ Say 8 in.	$P_a = 70 + 60 = 130 \text{ k}$ Allowable strength of $\frac{7}{16}$ in. welds $= \frac{(0.60 \times 80)(0.309)(1)}{2.00} = 7.42 \text{ k/in.}$ weld length reqd $= \frac{130}{7.42} = 17.52 \text{ in.}$ $P_2 = (6)(7.42) = 44.52 \text{ k}$ Taking moments about point A on sketch $-(44.52)(3) - 6P_3 + (130)(1.98) = 0$ $P_3 = 20.65 \text{ k}$ $L_3 = \frac{20.65}{7.42} = 2.78 \text{ in.}$ Say 3 in. $L_1 = 17.52 - 6 - 2.78 = 8.74 \text{ in.}$ Say 9 in.

✓ JCM

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EXCLUSIVE: Just in Edutruth only

PROB #14-14



$$\text{max weld size} = \frac{3}{4} - \frac{1}{16} = \frac{11}{16} \text{ in.}$$

$$\text{Effective throat} = (0.707) \left(\frac{11}{16} \right) = 0.486 \text{ in.}$$

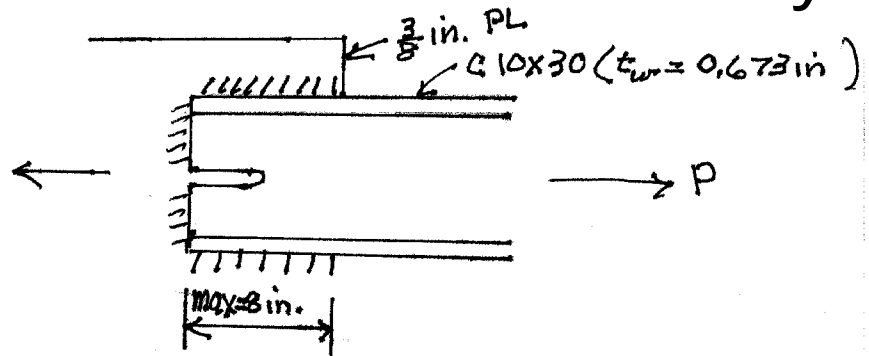
LRFD $\phi = 0.75$	ASD $\Omega = 2.00$
$P_u = (1.2)(170) + (1.6)(200) = 524 \text{ k}$ Design strength/in. of $\frac{11}{16}$ welds $= (0.75)(0.6 \times 70)(0.486)(1) = 15.31 \text{ k/in.}$ Total weld length $= \frac{524}{15.31} = 34.23 \text{ in.}$ $P_2 = (8)(15.31) = 122.5 \text{ k}$ Taking moments about pt. A $-(122.5)(4) - 8P_3 + (524)(2.26) = 0$ $P_3 = 86.8 \text{ k}$ $L_3 = \frac{86.8}{15.31} = 5.67 \text{ in.}$ Say 6 in. $P_1 = 524 - 122.5 - 86.8 = 314.7 \text{ k}$ $L_1 = \frac{314.7}{15.31} = 20.56 \text{ in.}$ Say 21 in.	$P_a = 170 + 200 = 370 \text{ k}$ Allow. strength/in. of $\frac{11}{16}$ welds $= \frac{(0.6 \times 70)(0.486)(1)}{2.00} = 10.21 \text{ k/in.}$ Total weld length reqd $= \frac{370}{10.21} = 36.24 \text{ in.}$ $P_2 = (8)(10.21) = 81.68 \text{ k}$ Taking moments about pt. A $-(81.68)(4) - 8P_3 + (370)(2.26) = 0$ $P_3 = 63.6 \text{ k}$ $L_3 = \frac{63.6}{10.21} = 6.23 \text{ in.}$ Say $6\frac{1}{2}$ in. $P_1 = 370 - 81.68 - 63.6 = 224.7 \text{ k}$ $L_1 = \frac{224.7}{10.21} = 22.0 \text{ in.}$ 22.0 in.

V J LMC

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EXCLUSIVE: Just in Edutruth only

PROB #14-15



LRFD	ASD
$P_u = (1.2)(80) + (1.6)(120) = 288 \text{ k}$	$P_a = 80 + 120 = 200 \text{ k}$

Using max. weld size = $\frac{3}{8} - \frac{1}{16} = \frac{5}{16} \text{ in.}$

Effective throat thickness = $(\frac{5}{16})(0.707) = 0.221 \text{ in.}$

Nominal shear capacity R_n of fillet weld

$$= (0.60)(70)(0.221)(8 + 10 + 8) = 241.3 \text{ k}$$

LRFD $\phi = 0.75$	ASD $\Omega = 2.00$
$\phi R_n = (0.75)(241.3) = 181 \text{ k} < 288 \text{ k}$	$\frac{R_n}{\Omega} = \frac{241.3}{2.00} = 120.6 \text{ k} < 200 \text{ k}$

As fillet weld strength is insufficient use slot welds

Min. width of slot = $t \text{ of PL } (\frac{3}{8}) + \frac{5}{16} = \frac{11}{16}$

Max width of slot = $(2\frac{1}{4})(\frac{5}{8}) = 1.41 \text{ in. or } \frac{23}{16} \text{ in.}$

Assume weld $t = \frac{5}{8} \text{ in. as } t_w = 0.673 \text{ in.}$

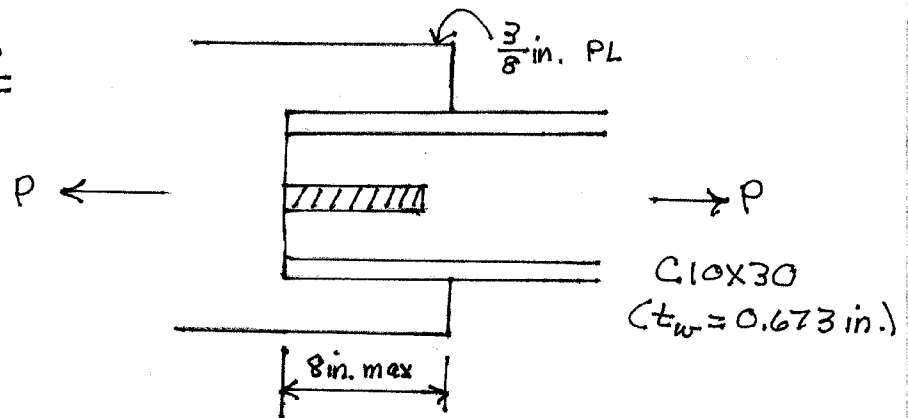
Use $\frac{15}{16} \text{ in. width}$

LRFD $\phi = 0.75$	ASD $\Omega = 2.00$
$\phi R_n \text{ for all welds must} = 288 \text{ k}$ $181 + (\frac{15}{16})(\frac{5}{8} \times 0.707)(0.6 \times 70)(0.75) = 171.8$ $171.8 + \phi(R_n \text{ of slot weld}) = 288 \text{ k}$ $171.8 + (0.75)(L)(\frac{15}{16} \times 0.6 \times 70) = 288$ $L = 3.93 \text{ in.}$	$\frac{R_n}{\Omega} \text{ for all of welds must} = 200 \text{ k}$ $120.6 + (\frac{15}{16})(\frac{5}{8} \times 0.707)(0.6 \times 70)(\frac{1}{2.00}) = 116.3$ $116.3 + \frac{(\frac{15}{16})(L)(0.6 \times 70)}{2.00} = 200$ $L = 4.25 \text{ in.}$
USE $\frac{15}{16} \text{ in. wide}$ slot weld 4 in. long	USE $\frac{15}{16} \text{ in. wide}$ slot weld $4\frac{1}{4} \text{ in. long}$

QCM

EXCLUSIVE: Just in Edutruth only

PROB #14-16



LRFD	ASD
$P_u = (1.2)(80) + (1.6)(120) = 288 \text{ k}$	$P_a = 80 + 120 = 200 \text{ k}$

$$\text{Max weld size} = \frac{3}{8} - \frac{1}{16} = \frac{5}{16} \text{ in.}$$

$$\text{Effective throat } t = \left(\frac{5}{16}\right)(0.707) = 0.221 \text{ in.}$$

$$\begin{aligned} \text{Nominal shear capacity } R_n \text{ of fillet weld} \\ = (0.60)(80)(0.221)(8+8+8) = 275.8 \text{ k} \end{aligned}$$

LRFD $\phi = 0.75$	ASD $\Omega = 2.00$
$\phi R_n = (0.75)(275.8) = 206.8 \text{ k} < 288 \text{ k}$	$\frac{R_n}{\Omega} = \frac{275}{2.00} = 137.5 \text{ k} < 200 \text{ k}$

As strength of fillet welds is insufficient
use slot weld.

EXCLUSIVE: Just in Edutruth only

PROB# 14-16 CONTD.

Minimum width of slot = $t \text{ of PL} + \frac{5}{16} = \frac{3}{8} + \frac{5}{16} = \frac{11}{16} \text{ in.}$

Maximum width of slot = $(2\frac{1}{4})(\frac{5}{8}) = 1.41 \text{ in. or } \frac{23}{16} \text{ in.}$

Use $\frac{15}{16} \text{ in. width}$

Assume weld thickness $t = \frac{5}{8} \text{ in.} < t_w = 0.673 \text{ in.}$

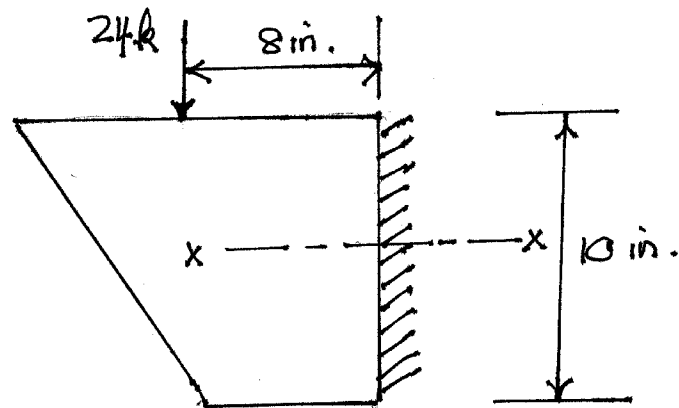
LRFD $\phi = 0.75$	ASD $\Omega = 2.00$
ϕR_n for all welds must be $\geq 288 \text{ k}$ $206.8 + 0.75(\frac{15}{16} \times L \times 0.60 \times 80)$ $= 288$ $L = 2.41 \text{ in.}$ <div style="border: 1px solid black; padding: 2px; display: inline-block;">USE $2\frac{1}{2} \text{ in}$ slot weld</div>	$\frac{R_n}{\Omega}$ for all welds must be $\geq 200 \text{ k}$ $137.5 + \frac{15/16 \times L \times 0.6 \times 80}{2.00} = 200$ $L = 2.78 \text{ in.}$ <div style="border: 1px solid black; padding: 2px; display: inline-block;">USE 3 in. slot weld</div>

✓ gc m

380

EXCLUSIVE: Just in Edutruth only

PROB #14-17



Assume 1 in weld

$$A = 10 \text{ in.}^2$$

$$I_x = \left(\frac{1}{12}\right)(1)(10)^3 = 83.3 \text{ in.}^4$$

$$I_y = \text{negligible}$$

$$J = I_x + I_y = 83.3 \text{ in.}^4$$

$$\Gamma = (24)(8) = 192 \text{ in.} \cdot \text{k}$$

$$f_H = \frac{\Gamma}{J} = \frac{(192)(5)}{83.3} = 11.52 \text{ k/in.}^2$$

$$\frac{P}{A} = \frac{24}{10} = 2.4 \text{ k/in.}^2$$

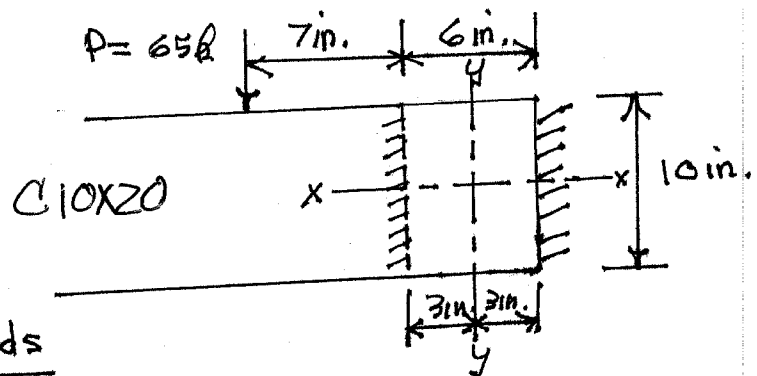
$$f_{\text{resultant}} = \sqrt{(11.52)^2 + (2.4)^2}$$
$$= 11.77 \text{ k/in.}^2 = \boxed{11.77 \text{ k/in.}}$$

✓ gcm

381

EXCLUSIVE: Just in Edutruth only

PROB #14-18



Assume lin. welds

$$A = (2)(10) = 20 \text{ in.}^2$$

$$I_x = \left(\frac{1}{12} \right) (10) (2)^3 = 166.7 \text{ in.}^4$$

$$I_y = \left[\left(\frac{1}{12} \right) (2) (10)^3 + (10)(3)^2 \right] (2) = 181.7 \text{ in.}^4$$

$$J = I_x + I_y = 166.7 + 181.7 = 348.4 \text{ in.}^4$$

$$T = (65) \left(7 + \frac{6}{2} \right) = 650 \text{ in.-lb}$$

$$f_H = \frac{T \cdot c}{J} = \frac{(650)(5)}{348.4} = 9.33 \text{ lb/in.}^2$$

$$f_V = \frac{T \cdot h}{J} = \frac{(650)(3)}{348.4} = 5.60 \text{ lb/in.}^2$$

$$\frac{P}{20} = \frac{65}{20} = 3.25 \text{ lb/in.}^2$$

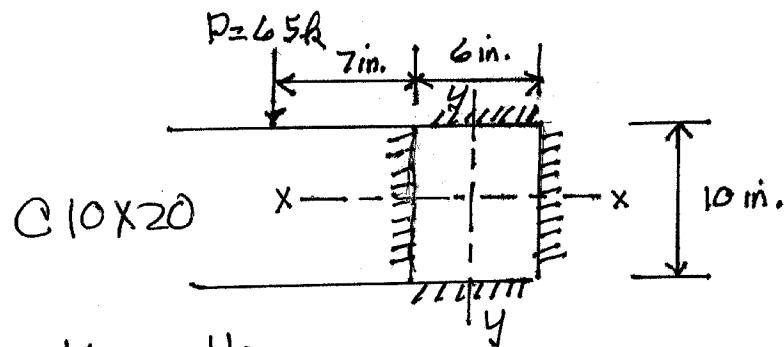
$$f_{res} = \sqrt{(9.33)^2 + (5.60 + 3.25)^2}$$

$$= 12.86 \text{ lb/in.}^2 = \boxed{12.86 \text{ lb/in.}^2}$$

✓ CM

EXCLUSIVE: Just in Edutruth only

PROB # 14-19



Assume 1 in. welds

$$A = (2)(10) + (2)(6) = 32 \text{ in.}^2$$

$$I_x = (2) \left[\left(\frac{1}{12} \right) (1) (10)^3 + \left(\frac{1}{12} \right) (6) (1)^3 + (6)(5)^2 \right] = 467.6 \text{ in.}^4$$

$$I_y = (2) \left[\left(\frac{1}{12} \right) (1) (6)^3 + \left(\frac{1}{12} \right) (10) (1)^3 + (10)(3)^2 \right] = 217.7 \text{ in.}^4$$

$$J = I_x + I_y = 467.6 + 217.7 = 685.3 \text{ in.}^4$$

$$T = (65) \left(7 + \frac{6}{2} \right) = 650 \text{ in.-lb}$$

$$f_H = \frac{T_v}{J} = \frac{(650)(5)}{685.3} = 4.74 \text{ lb/in.}^2$$

$$f_v = \frac{T_h}{J} = \frac{(650)(3)}{685.3} = 2.85 \text{ lb/in.}^2$$

$$\frac{P}{A} = \frac{65}{32} = 2.03 \text{ lb/in.}^2$$

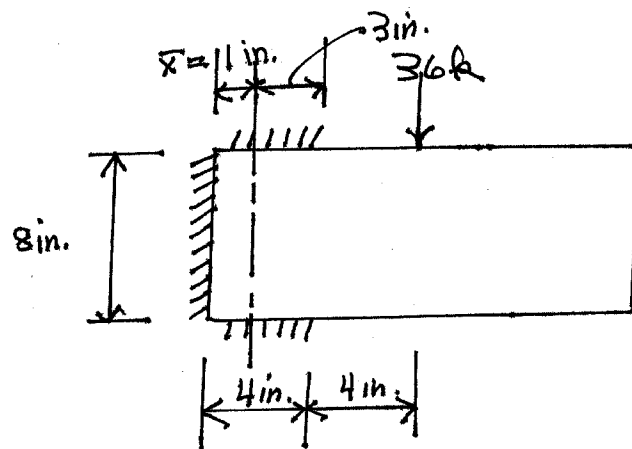
$$f_{\text{res}} = \sqrt{(4.74)^2 + (2.85 + 2.03)^2}$$

$$= 6.80 \text{ lb/in.}^2 = \boxed{6.80 \text{ lb/in.}^2}$$

VGCME

EXCLUSIVE: Just in Edutruth only

PROB # 14-20



Assume 1 in. welds

$$A = (2)(4) + 8 = 16 \text{ in.}^2$$

$$\bar{x} = \frac{(2)(4)(2)}{16} = 1 \text{ in.}$$

$$I_x = \left(\frac{1}{12}\right)(1)(8)^3 + (2)\left[\frac{1}{12}\right](4)(1)^3 + (4)(4)^2 = 171.3 \text{ in.}^4$$

$$I_y = \left(\frac{1}{12}\right)(8)(1)^3 + (8)(1)^2 + 2\left[\left(\frac{1}{12}\right)(1)(1)^3 + \left(\frac{1}{12}\right)(1)(3)^3\right] = 27.3 \text{ in.}^4$$

$$J = I_x + I_y = 171.3 + 27.3 = 198.6 \text{ in.}^4$$

$$T = (36)(4 + 3) = 252 \text{ in.-k}$$

$$f_H = \frac{T_v}{J} = \frac{(252)(4)}{198.6} = 5.08 \text{ k/in.}^2$$

$$f_V = \frac{T_h}{J} = \frac{(252)(3)}{198.6} = 3.81 \text{ k/in.}^2$$

$$\frac{P}{A} = \frac{36}{16} = 2.25 \text{ k/in.}^2$$

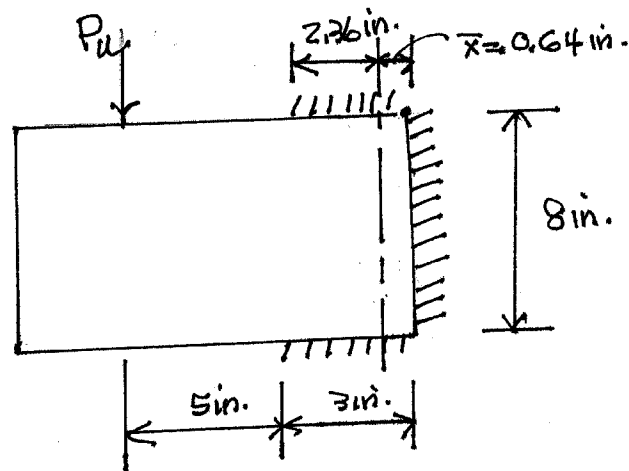
$$f_{res} = \sqrt{(5.08)^2 + (3.81 + 2.25)^2}$$

$$= 7.91 \text{ k/in.}^2 = \boxed{7.91 \text{ k/in.}^2}$$

vgcm

EXCLUSIVE: Just in Edutruth only

PROB # 14-21



(a) For simplification assume all welds have same strength thus neglecting fact that the horizontal welds are transverse to the load.

$$\phi P_m \text{ per in.} = \phi F_w A_w = (0.75)(0.6 \times 70)(0.707 \times \frac{1}{4} \times 1) = 5.57 \text{ k/in.}$$

Assume 1 in. welds

$$A = (2 \times 3) + 8 = 14 \text{ in.}^2$$

$$\bar{x} = \frac{(2 \times 3)(1.5)}{14} = 0.64 \text{ in.}$$

$$M_u = (P_u)(7.36) = 7.36 P_u$$

$$I_x = (\frac{1}{12})(1)(8)^3 + 2 \left[(\frac{1}{12})(3)(1)^3 + (3)(4)^2 \right] = 139.17 \text{ in.}^4$$

$$I_y = (\frac{1}{12})(8)(1)^3 + (8)(0.64)^2 + (2) \left[(\frac{1}{12})(1)(3)^3 + (\frac{1}{12})(1)(2.36)^3 \right] = 12.89 \text{ in.}^4$$

$$J = I_x + I_y = 139.17 + 12.89 = 152.1 \text{ in.}^4$$

$$f_H = \frac{T_v}{J} = \frac{(7.36 P_u)(4)}{152.1} = 0.1936 P_u$$

$$f_V = \frac{T_h}{J} = \frac{(7.36 P_u)(2.36)}{152.1} = 0.1142 P_u$$

$$\frac{P_u}{A} = \frac{P_u}{14} = 0.0714 P_u$$

$$f_{res} = \sqrt{(0.1936 P_u)^2 + (0.1142 P_u + 0.0714 P_u)^2} = 0.268 P_u \text{ k/in.}^2$$

Equating

$$0.268 P_u = 5.57 \text{ k/in.}$$

$$\boxed{P_u = 20.8 \text{ k}}$$

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EXCLUSIVE: Just in Edutruth only

PROB[#] 14-21 CONTD.

(b) From AISC Tables 8-8 and 8-3

$$C_1 = 1.00$$

$$L = 8 \text{ in}$$

$$kL = 3 \text{ in}$$

$$k = 0.375$$

$$D = 4$$

$$a = \frac{e_x}{L} = \frac{7.36}{8} = 0.92$$

$$C = 1.4905$$

$$P_m = CC, DL$$

$$= (1.4905)(1.00)(4)(8) = 47.7 \text{ k}$$

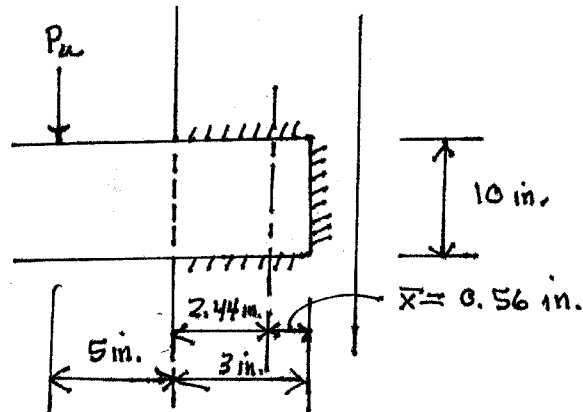
$$\phi P_m = (0.75)(47.7) = \boxed{35.77 \text{ k}}$$

VJCMC

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EXCLUSIVE: Just in Edutruth only

PROB #14-22



(a) For simplification assume all welds have same strength ~~per in.~~ neglecting fact that the horizontal welds are transverse to the load.

$$\phi P_n \text{ per in.} = \phi F_w A_w = (0.75)(0.6 \times 70)(0.707 \times \frac{3}{8})(1) = 8.95 \text{ k/in.}$$

Assume lin. welds

$$A = (2)(3) + 10 = 16 \text{ in.}^2$$

$$\bar{x} = \frac{(2)(3)(1.5)}{16} = 0.56 \text{ in.}$$

$$M_u = (P_u)(7.44) = 7.44 P_u$$

$$I_x = (\frac{1}{12})(1)(10)^3 + 2[(\frac{1}{12})(3)(1)^3 + (3)(5)^2] = 233.8 \text{ in.}^4$$

$$I_y = (\frac{1}{12})(10)(1)^3 + (10)(0.56)^2 + (2)[(\frac{1}{12})(1)(0.56^3 + 2.44^3)] = 13.8 \text{ in.}^4$$

$$J = I_x + I_y = 233.8 + 13.8 = 247.6 \text{ in.}^4$$

$$f_H = \frac{T_v}{J} = \frac{(7.44 P_u)(5)}{247.6} = 0.150 P_u$$

$$f_v = \frac{T_h}{J} = \frac{(7.44 P_u)(2.44)}{247.6} = 0.0733 P_u$$

$$\frac{P_u}{A} = \frac{P_u}{16} = 0.0625 P_u$$

$$f_{res} = \sqrt{(0.150 P_u)^2 + (0.0733 P_u + 0.0625 P_u)^2} = 0.202 P_u \text{ k/in.}^2$$

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EXCLUSIVE: Just in Edutruth only

PROB # 14-22 CONTD.

$$8.35 = 0.202 P_u$$

$$\boxed{\phi P_m = 41.3 \text{ k}}$$

(b) From AISC Tables 8-8 and 8-3

$$C_1 = 1.00$$

$$L = 10 \text{ in.}$$

$$kL = 3 \text{ in.}$$

$$h = 0.3$$

$$D = 6$$

$$a = \frac{e_x}{L} = \frac{7.44}{10} = 0.744$$

$$C = 1.58$$

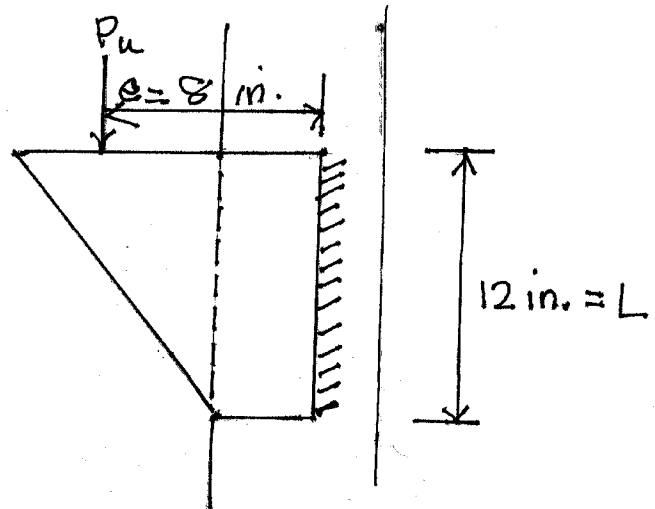
$$R_m = C C_1 D L$$

$$= (1.58)(1.00)(6)(10) = \boxed{94.8 \text{ k}}$$

\checkmark gcm

EXCLUSIVE: Just in Edutruth only

PROB # 14-23



LRFD
$P_u = (1.2)(10) + (1.6)(10) = 28 \text{ k}$

(a) Assume 1 in. weld

$$A = (12)(1) = 12 \text{ in.}^2$$

$$T = (28)(8) = 224 \text{ in.-k}$$

$$I_x = \left(\frac{1}{12}\right)(1)(12)^3 = 144 \text{ in.}^4$$

$$I_y = \text{negligible}$$

$$J = I_x + I_y = 144 \text{ in.}^4$$

$$f_H = \frac{Tv}{J} = \frac{(224)(6)}{144} = 9.33 \text{ k/in.}^2$$

$$\frac{P_u}{A} = \frac{28}{12} = 2.33 \text{ k/in.}^2$$

$$f_{res} = \sqrt{(9.33)^2 + (2.33)^2} = 9.62 \text{ k/in.}^2$$

$$\text{Weld size reqd} = \frac{f_{res}}{\phi F_w A_w}$$

$$= \frac{9.62}{(0.75)(0.6 \times 70)(0.707 \times 1)(1)} = 0.432 \text{ in.} = \text{Say } \frac{7}{16} \text{ in.}$$

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EXCLUSIVE: Just in Edutruth only <http://edutruth.4shared.com>

EXCLUSIVE: Just in Edutruth only

PROB #14-23 CONTD.

(b) Using AISC Table 8-10

$$P_u = 28 \text{ k}$$

$$a = \frac{e}{L} = \frac{8}{12} = 0.667$$

$$C = 0.997 - (0.667)(0.997 - 0.879) = 0.918$$

$$C_1 = 1.0 \text{ for E70 electrodes}$$

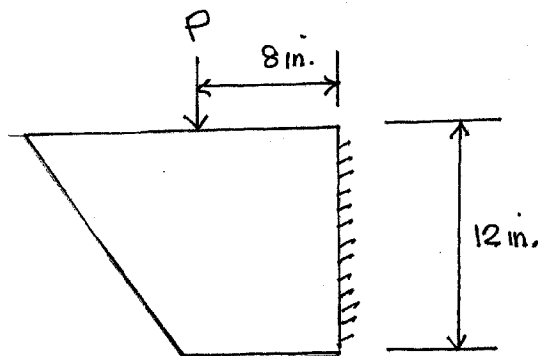
$$D_{\min.} = \frac{P_u}{\phi C C_1 L} = \frac{28}{(0.75)(0.918)(1.0)(12)}$$
$$= \frac{3.39}{16} = 0.212 \text{ in.}$$

USE $\frac{1}{4}$ in.
weld size

$\checkmark \text{ gcm} \equiv$

EXCLUSIVE: Just in Edutruth only

PROB# 14-24



Assume 1-in. weld

$$P_a = 10 + 10 = 20 \text{ k}$$

$$A = 12 \text{ in.}^2$$

$$T = (20)(8) = 160 \text{ in.-k}$$

$$I_x = \left(\frac{1}{12}\right)(1)(12)^3 = 144 \text{ in.}^4$$

$$I_y = 0$$

$$J = 144 \text{ in.}^4$$

$$f_H = \frac{T_y}{J} = \frac{(160)(6)}{144} = 6.67 \text{ k/in.}^2$$

$$f_v = 0$$

$$\frac{P}{12} = \frac{20}{12} = 1.67 \text{ k/in.}^2$$

$$f_{\text{resultant}} = \sqrt{(6.67)^2 + (1.67)^2} = 6.88 \text{ k/in.}^2$$

ASD strength per inch of a 1-in. weld

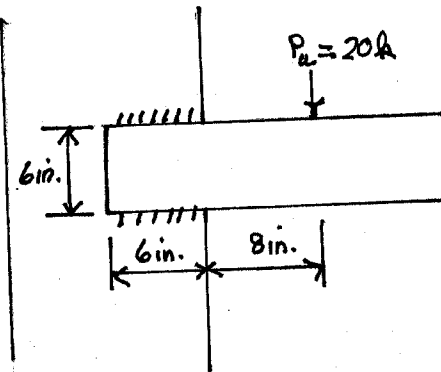
$$= \frac{(0.60 \times 70)(1.00 \times 0.707)}{2} = 14.85 \text{ k/in.}$$

$$\text{Weld size reqd} = \frac{6.88}{14.85} = 0.463 \text{ in. Say } \frac{1}{2} \text{ in.}$$

✓ OK

EXCLUSIVE: Just in Edutruth only

PROB # 14-25



(a) Assume lin. welds

$$A = (2)(6 \times 1) = 12 \text{ in.}^2$$

$$I_x = (2)(6)(3)^2 = 108 \text{ in.}^4$$

$$I_y = (2)\left(\frac{1}{12}\right)(1)(6)^3 = 36 \text{ in.}^4$$

$$J = 108 + 36 = 144 \text{ in.}^4$$

$$T = (20)\left(8 + \frac{6}{2}\right) = 220 \text{ in. k} \rightarrow$$

$$f_H = \frac{T_V}{J} = \frac{(220)(3)}{144} = 4.58 \text{ k/in.}^2$$

$$f_V = \frac{T_H}{J} = \frac{(220)(3)}{144} = 4.58 \text{ k/in.}^2$$

$$\frac{P_u}{16} = \frac{20}{12} = 1.67 \text{ k/in.}^2$$

$$f_{res} = \sqrt{(4.58)^2 + (4.58 + 1.67)^2} = 7.75 \text{ k/in.}^2$$

$$\text{weld size reqd} = \frac{7.75}{(0.75)(0.707)\left(\frac{1}{16}\right)(0.6 \times 70)}$$

$$= \frac{5.57}{16}$$

USE $\frac{3}{8}$ in.

EXCLUSIVE: Just in Edutruth only

PROB # 14-25 CONTD.

(b) Solution of same problem using AISC Table 8-5

$$P_u = 20 \text{ k}$$

$$L = 60 \text{ in.}$$

$$e_x = 8 + 3 = 11 \text{ in.}$$

$$a = \frac{e_x}{L} = \frac{11}{60} = 1.833$$

$$kL = 60 \text{ in.}$$

$$k(6) = 6$$

$$k = 1.00$$

$$C_1 = 1.00 \text{ for E70 electrodes}$$

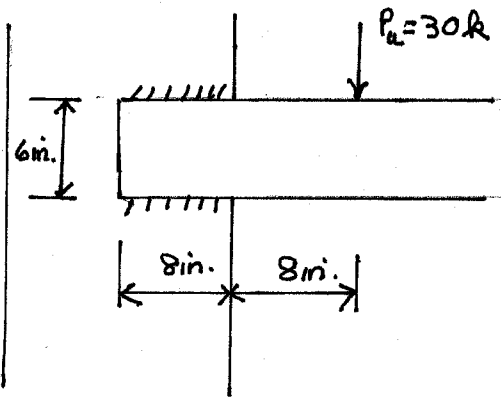
$$C \text{ from table} = 1.25$$

$$D_{min} = \frac{P_u}{\phi C C_1 L} = \frac{20}{(0.75)(1)(1.25)(60)}$$
$$= \frac{3.55}{16} \quad \boxed{\text{say } \frac{1}{4} \text{ in.}}$$

✓ JCM

EXCLUSIVE: Just in Edutruth only

PROB# 14-26



(a) Assume 1 in. welds

$$A = (2)(8) = 16 \text{ in.}^2$$

$$I_x = (2)(8)(3)^2 = 144 \text{ in.}^4$$

$$I_y = (2)\left(\frac{1}{12}\right)(1)(8)^3 = 85.33 \text{ in.}^4$$

$$J = I_x + I_y = 144 + 85.33 = 229.3 \text{ in.}^4$$

$$T = (30)(12) = 360 \text{ in.-k} \rightarrow$$

$$f_H = \frac{T_V}{J} = \frac{(360)(3)}{229.3} = 4.71 \text{ k/in.}^2 \rightarrow$$

$$f_V = \frac{T_H}{J} = \frac{(360)(4)}{229.3} = 6.28 \text{ k/in.}^2 \downarrow$$

$$\frac{P_u}{16} = \frac{30}{16} = 1.875 \text{ k/in.}^2 \downarrow$$

$$f_{res} = \sqrt{(4.71)^2 + (6.28 + 1.875)^2} = 9.42 \text{ k/in.}^2$$

$$\begin{aligned} \text{weld size reqd} &= \frac{9.42}{(0.75)(0.707 \times \frac{1}{16})(0.6 \times 70)} \\ &= \frac{6.77}{16} \quad \boxed{\text{Say } \frac{7}{16} \text{ in.}} \end{aligned}$$

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EXCLUSIVE: Just in Edutruth only

PROB #14-26 CONTD

(b) Repeating Problem with AISC Table 8-5

$$P_u = 30k$$

$$L = 8 \text{ in.}$$

$$e_x = 8 + 4 = 12 \text{ in.}$$

$$kL = 6 \text{ in.}$$

$$(kL/r) = 6$$

$$k = 1.0$$

$$C_1 = 1.00 \text{ for E70 electrodes}$$

$$C \text{ from table} = 1.28$$

$$D_{min} = \frac{P_u}{\phi C C_1 L}$$

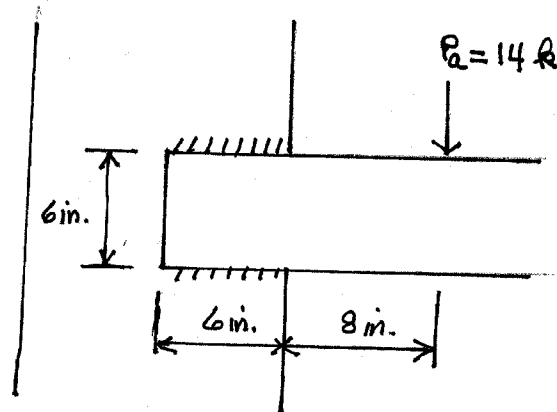
$$= \frac{30}{(0.75)(1.28)(1.0)(8)} = 3.90$$

$$= \frac{3.90}{16} \quad \boxed{\text{say } \frac{1}{4} \text{ in.}}$$

✓ J @ MC

EXCLUSIVE: Just in Edutruth only

PROB #14-27



(a) Assume 1 in. welds

$$A = (2)(6) = 12 \text{ in.}^2$$

$$I_x = (2)(6)(3)^2 = 108 \text{ in.}^4$$

$$I_y = (2)(\frac{1}{12})(1)(6)^3 = 36 \text{ in.}^4$$

$$J = I_x + I_y = 108 + 36 = 144 \text{ in.}^4$$

$$T = (14)(8 + \frac{6}{2}) = 154 \text{ in. k} \rightarrow$$

$$f_H = \frac{Tv}{J} = \frac{(154)(3)}{144} = 3.21 \text{ k/in.}^2$$

$$f_V = \frac{Th}{J} = \frac{(154)(3)}{144} = 3.21 \text{ k/in.}^2$$

$$\frac{P_a}{A} = \frac{14}{12} = 1.17 \text{ k/in.}^2$$

$$f_{res} = \sqrt{(3.21)^2 + (3.21 + 1.17)^2} = 5.43 \text{ k/in.}^2$$

$$\text{weld size reqd} = \frac{f_{res}}{(\frac{1}{2} \times \text{weld size})(0.6 F_{EXX})}$$

$$= \frac{5.43}{(\frac{1}{2.00})(0.707 \times 1)(0.6 \times 70)}$$

$$= 0.366 \text{ in.} \quad \boxed{\text{Say } \frac{3}{8} \text{ in.}}$$

396

EXCLUSIVE: Just in Edutruth only

PROB # 14-27 CONTD.

(b) Repeating problem with AISC Table 8-5

$$P_a = 14 \text{ k}$$

$$L = 6 \text{ in.}$$

$$e_x = 8 + 3 = 11 \text{ in.}$$

$$a = \frac{e_x}{L} = \frac{11}{6} = 1.833$$

$$kL = 6 \text{ in.}$$

$$k(b) = 6$$

$$k = 1.00$$

$$C_1 = 1.00 \text{ for E70 electrode}$$

$$C \text{ from table} = 1.25$$

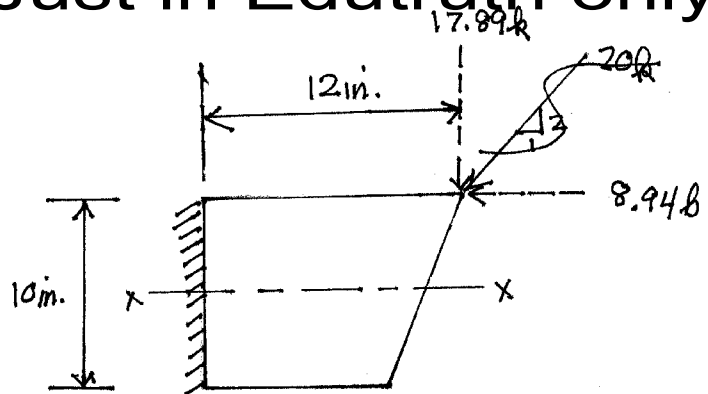
$$D \text{ min.} = \frac{(2.00)(14)}{(1.25)(1)(6)} = \frac{3.73}{16}$$

USE $\frac{1}{4}$ weld

vgcmm

EXCLUSIVE: Just in Edutruth only

PROB #14-28



(a) Assume 1 in. weld

$$A = 10 \text{ in.}^2$$

$$I_x = \left(\frac{1}{12}\right)(1)(10)^3 = 83.3 \text{ in.}^4$$

$$I_y = \text{negligible}$$

$$J = I_x + I_y = 83.3 \text{ in.}^4$$

$$T = (17.89)(12) - (8.94)(5) = 170 \text{ in.} \cdot \text{lb} \downarrow$$

$$f_h = \frac{T_y}{J} = \frac{(170)(5)}{83.3} = 10.20 \text{ lb/in.}^2 \leftarrow$$

$$\frac{8.94}{10} = 0.894 \text{ lb/in.}^2 \leftarrow$$

$$\frac{17.89}{10} = 1.789 \text{ lb/in.}^2 \downarrow$$

$$f_{res} = \sqrt{(10.20 + 0.894)^2 + (1.789)^2} = 11.24 \text{ lb/in.}^2$$

$$\text{weld size reqd} = \frac{f_{res}}{(\phi)(\text{weld size})(0.6 F_{EXX})}$$

$$= \frac{11.24}{(0.75)(0.707 \times 10)(0.6 \times 70)}$$

$$= 0.505 \text{ in.}$$

USE $\frac{1}{2}$ in. WELD

vgc mc

EXCLUSIVE: Just in Edutruth only

PROB # 14-28 CONTD.

(b) using AISC Table 8-10

e_x = horizontal component of eccentricity of P_u
with respect to weld centroid = 9.5 in.

$$a = \frac{9.5}{10} = 0.95$$

$$b = 0$$

$$C = \frac{0.781 + 0.713}{2} = 0.747$$

$$D_{min} = \frac{P_u}{\phi C C_1 e} = \frac{20}{(0.75)(0.747)(1.0)(10)}$$

$$= \frac{3.57}{16} \quad \boxed{\text{say } \frac{1}{4} \text{ in.}}$$

\checkmark gcm^c

EXCLUSIVE: Just in Edutruth only

PROB # 14-29 CONTD

Nominal strength of 1-in. weld

$$= (0.60 \times 70) (1 \times 0.707 \times 1.0) = 29.69 \text{ k/in.}^2$$

ASD allowable strength of weld = $\frac{29.69}{\Omega}$

$$= \frac{29.69}{2.00} = 14.85 \text{ k/in.}^2$$

$$\text{weld size reqd.} = \frac{2.68}{14.85} = 0.181 \text{ in.}$$

USE $\frac{3}{16}$ in. welds and $3 \times 3 \times \frac{1}{4}$ angles

(b) using AISC Table 8-8

$$P = 30 \text{ k for 1 weld}$$

$$L = 12 \text{ in.}$$

$$e_x = \frac{1}{2} + 2.132 = 2.623 \text{ in.}$$

$$a = \frac{e_x}{L} = \frac{2.623}{12} = 0.219$$

$$kL = 2.50 \text{ in.}, k = \frac{2.5}{12} = 0.208$$

$$C \text{ from table} = 2.62$$

$$C_1 = 1.0 \text{ for E70 electrode}$$

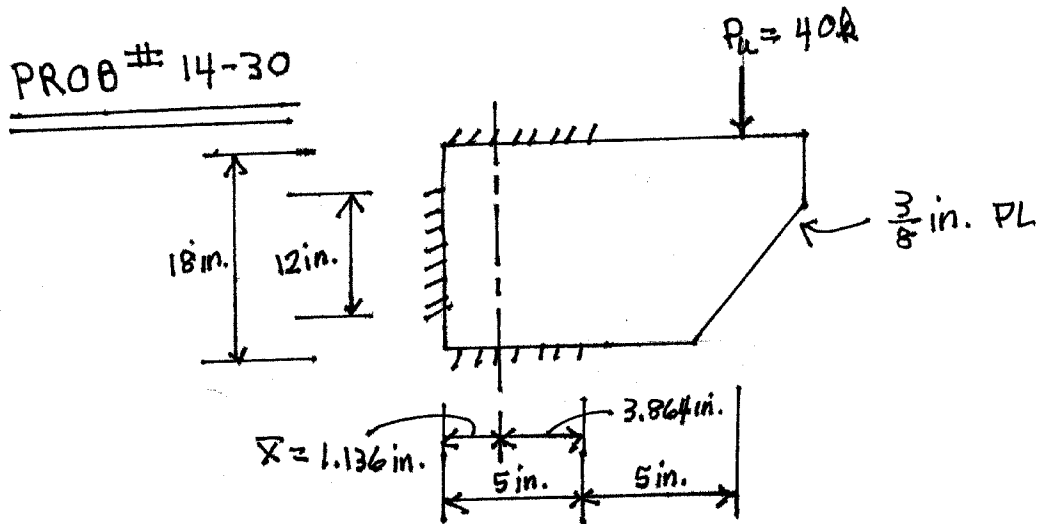
$$D_{\min} = \frac{\Omega P_a}{C C_1 L} = \frac{(2.00)(30)}{(2.62)(1)(12)} = \frac{1.908}{16}$$

USE $\frac{1}{8}$ in. welds
and $3 \times 3 \times \frac{3}{16}$ Ls

✓ JCM

401

EXCLUSIVE: Just in Edutruth only



Assume 1 in. welds

$$A = 12 + 5 + 5 = 22 \text{ in.}^2$$

$$\bar{x} = \frac{(2)(5)(2.5)}{22} = 1.136 \text{ in.}$$

$$T = (40)(5 + 3.864) = 354.6 \text{ in.-k}$$

$$I_x = \left(\frac{1}{12}\right)(1)(12)^3 + (2)(5)(9)^2 = 954 \text{ in.}^4$$

$$I_y = (2)\left(\frac{1}{12}\right)(1)(1.136^3 + 3.864^3) + (2)(1.136)^2 = 54.9 \text{ in.}^4$$

$$J = I_x + I_y = 954 + 54.9 = 1008.9 \text{ in.}^4$$

$$f_H = \frac{T_v}{J} = \frac{(354.6)(9)}{1008.9} = 3.16 \text{ k/in.}^2$$

$$f_v = \frac{T_h}{J} = \frac{(354.6)(3.864)}{1008.9} = 1.358 \text{ k/in.}^2$$

$$\frac{P_u}{A} = \frac{40}{22} = 1.818 \text{ k/in.}^2$$

$$f_{\text{resultant}} = \sqrt{(3.16)^2 + (1.358 + 1.818)^2} = 4.48 \text{ k/in.}^2$$

$$\text{weld size reqd} = \frac{4.48}{(0.75)(0.6)(70)(1 \times 0.707)}$$

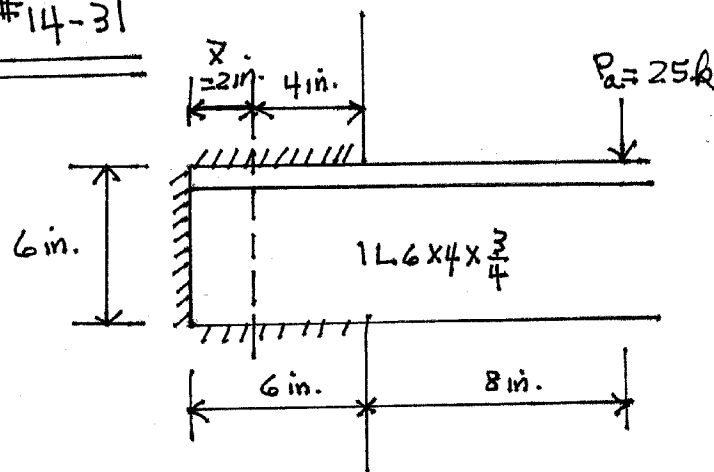
$$= 0.201 \text{ in.} \quad \boxed{\text{USE } \frac{1}{4} \text{ in.}}$$

✓ JCMC

402

EXCLUSIVE: Just in Edutruth only

PROB #14-31



(a) Using ASD method

Assume 1-in. welds

$$A = 18 \text{ in.}^2$$

$$\bar{x} = \frac{(2)(6)(3)}{18} = 2 \text{ in.}$$

$$T = (25)(8+4) = 300 \text{ in.-k} \rightarrow$$

$$I_x = \left(\frac{1}{12}\right)(1)(6)^3 + (2)(6)(3)^2 = 126 \text{ in.}^4$$

$$I_y = \left[\left(\frac{1}{12}\right)(1)(2^3 + 4^3)\right] 2 + (6)(2)^2 = 72 \text{ in.}^4$$

$$J = 126 + 72 = 198 \text{ in.}^4$$

Considering horizontal welds

$$\frac{P_u}{18} = \frac{25}{18} = 1.39 \text{ k/in.} \downarrow$$

$$f_v = \frac{(300)(4)}{198} = 6.06 \text{ k/in.} \downarrow$$

$$f_H = \frac{(300)(3)}{198} = 4.55 \text{ k/in.} \rightarrow$$

$$f_{\text{resultant}} = \sqrt{(1.39+6.06)^2 + (4.55)^2} = 8.73 \text{ k/in.}$$

To simplify calculations no increase in connection strength is assumed to occur due to transverse welds.

EXCLUSIVE: Just in Edutruth only

PROB #14-31 CONTD.

$$\text{Allowable strength welds} = \frac{(0.6 \times 70)(0.707 \times 1)(1)}{2.00}$$

$$= 14.85 \text{ k/in.}$$

$$\text{Weld size reqd.} = \frac{8.73}{14.85} = 0.588 \text{ in. Say } \underline{\underline{\frac{5}{8} \text{ in.}}}$$

(b) Using AISC Table 8-8 and ASD method

$$L = 6 \text{ in.}$$

$$e_x = aL$$

$$12 = (a)(6)$$

$$a = 2.00$$

$$xL = 2 \text{ in.}$$

$$(x)(6) = 2$$

$$x = 0.333$$

$$k = \frac{6}{6} = 1.00$$

C from table =

$$C_1 = 1.00 \text{ from AISC Table 8-3}$$

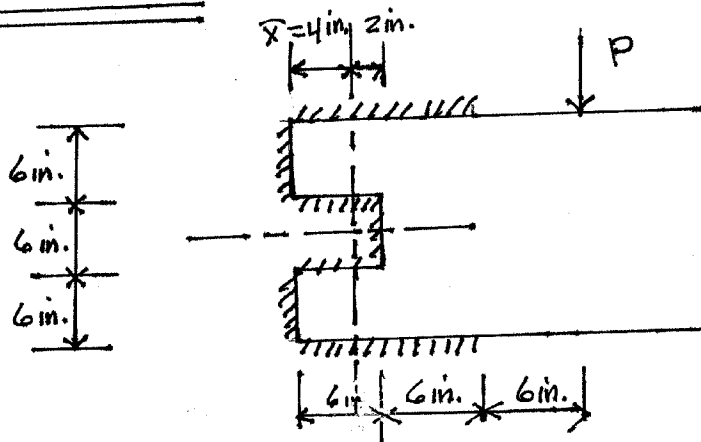
$$\begin{aligned} \text{Weld size } D_{\min} &= \frac{R_u}{C_1 L} = \frac{(2.00)(25)}{(1.64)(1.00)(6)} \\ &= \frac{5.08}{16} \text{ Say } \underline{\underline{\frac{3}{8} \text{ in.}}} \end{aligned}$$

✓ gcm

404

EXCLUSIVE: Just in Edutruth only

PROB#14-32



Assume 1-in. weld

$$A = (2)(12) + (2)(6) + 18 = 54 \text{ in.}^2$$

$$\bar{x} = \frac{(2)(12)(6) + (2)(6)(3) + (6)(6)}{54} = 4 \text{ in.}$$

$$T = 14P \searrow$$

$$I_x = \left(\frac{1}{12}\right)(1)(18)^3 + (2)(6)(3)^2 + (2)(12)(9)^2 = 2538 \text{ in.}^4$$

$$I_y = \left(\frac{1}{3}\right)(1)(4)^3(4) + \left(\frac{1}{3}\right)(1)(2)^3(2) + \left(\frac{1}{3}\right)(1)(8)^3(12) + (2)(4)^2 + (6)(2)^2 = 648 \text{ in.}^4$$

$$J = 2538 + 648 = 3186 \text{ in.}^4$$

Maximum force/in. in horizontal welds

$$\frac{P}{54} = 0.01852 P \downarrow$$

$$f_H = \frac{(14P_u)(9)}{3186} = 0.03955 P_u \rightarrow$$

$$f_V = \frac{(14P_u)(8)}{3186} = 0.03515 P \downarrow$$

$$f_{\text{resultant}} = \sqrt{(0.03955 P)^2 + (0.01852 P + 0.03515 P)^2} = 0.0667 P$$

EXCLUSIVE: Just in Edutruth only

PROB# 14-32 CONTD

R_m = nominal strength of weld per in.

$$= F_w A_w = (0.6)(70) \left(\frac{3}{8} \times 0.707 \right) = 11.14 \text{ k/in.}$$

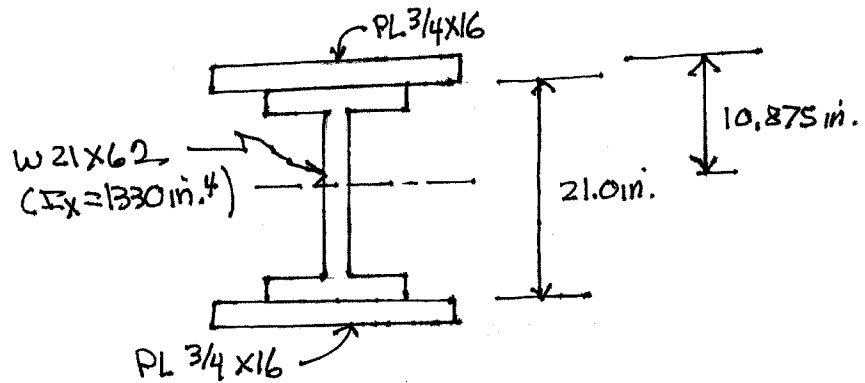
LRFD $\phi = 0.75$	ASD $\Omega = 2.00$
$\phi R_m = (0.75)(11.14) = 8.35 \text{ k/in.}$ $0.0667 P_u = 8.35$ $P_u = 125.2 \text{ k}$	$\frac{R_m}{\Omega} = \frac{11.14}{2.00} = 5.57 \text{ k/in.}$ $0.0667 P_a = 5.57$ $P_a = 83.5 \text{ k}$

✓ JCMC

406

EXCLUSIVE: Just in Edutruth only

PROB # 14-33



$$I_x = 1330 + (2) \left(\frac{3}{4} \right) (16) (10.875)^2 = 4168 \text{ in.}^4$$

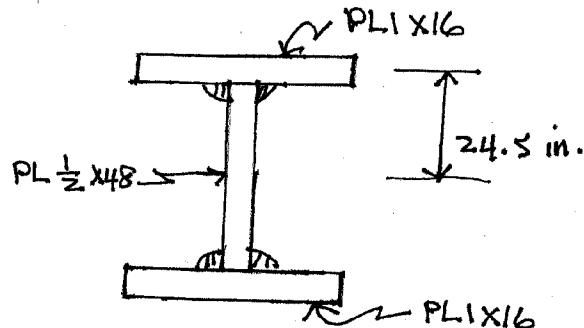
$$Q = \left(\frac{3}{4} \right) (16) (10.875) = 130.5 \text{ in.}^3$$

LFRD $\phi = 0.75$	ASD $\Omega = 2.00$
$f_v/\text{in.} = \frac{V_u Q}{I_x} = \frac{(95)(130.5)}{4168}$ $= 2.97 \text{ k/in.}^2$ <p>Strength per in. of $\frac{1}{4}$-in. welds</p> $= (0.75)(0.6 \times 70) \left(\frac{1}{4} \times 0.707 \right)$ $= 5.57 \text{ k/in.}$ <p>Length of welds every 12 in.</p> $= \frac{(12)(2.97)}{2 \times 5.57} = 3.20 \text{ in.}$ <p>USE $3\frac{1}{2}$ in.</p>	$f_v/\text{in.} = \frac{V_u Q}{I_x} = \frac{(65)(130.5)}{4168}$ $= 2.04 \text{ k/in.}$ <p>Strength per in. of $\frac{1}{4}$-in. weld</p> $= \frac{F_w A_w}{2}$ $= \frac{(0.60)(70) \left(\frac{1}{4} \times 0.707 \right)}{2.00}$ $= 3.71 \text{ k/in.}$ <p>Length of weld every 12 in.</p> $= \frac{(12)(2.04)}{(2)(3.71)} = 3.30 \text{ in.}$ <p>USE $3\frac{1}{2}$ in.</p>

✓ GCM

EXCLUSIVE: Just in Edutruth only

PROB #14-34



$$Q = (16)(24.5) = 392 \text{ in.}^3$$

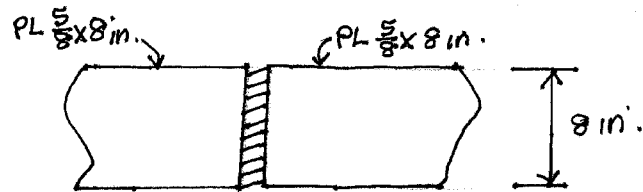
$$I_x = \left(\frac{1}{12}\right)\left(\frac{1}{2}\right)(48)^3 + (2)(16)(24.5)^2 = 23,816 \text{ in.}^4$$

LRFD $\phi = 0.75$	ASD $\Omega = 2.00$
$V_u = (1.2)(300) + (1.6)(350) = 920 \text{ k}$ $f_v/\text{in.} = \frac{V_u Q}{I_x} = \frac{(920)(392)}{23,816}$ $= 15.14 \text{ k/in.}$ Design strength of 1 in Fillet weld $= \phi F_w A_w = (0.75)(0.6 \times 70)(1.0)(1.0 \times 0.707)$ $= 22.27 \text{ k/in.}$ Fillet weld size reqd $= \frac{15.14}{2 \times 22.27} = 0.340 \text{ in.}$ <div style="border: 1px solid black; padding: 2px; display: inline-block;">USE $\frac{3}{8}$-in welds</div>	$V_a = 300 + 350 = 650 \text{ k}$ $f_v/\text{in.} = \frac{V_a Q}{I_x} = \frac{(650)(392)}{23,816}$ $= 10.70 \text{ k/in.}$ Allowable strength of 1 in. fillet weld $= \frac{F_w A_w}{\Omega}$ $= \frac{(0.60)(70)(1.0 \times 0.707)(1)}{2.00} = 14.85 \text{ k/in.}$ Fillet weld size reqd $= \frac{10.70}{2 \times 14.85} = 0.360 \text{ in.}$ <div style="border: 1px solid black; padding: 2px; display: inline-block;">USE $\frac{3}{8}$-in. welds</div>

✓ JCMC

EXCLUSIVE: Just in Edutruth only

PROB# 14-35



(a) Full penetration groove weld

$$R_m = \text{strength of base metal} = F_y A_g$$

$$= (36) \left(\frac{5}{8} \times 8 \right) = 180k$$

LRFD $\phi = 0.90$	ASD $\Omega = 1.67$
$\phi R_m = (0.9)(180) = \underline{\underline{162k}}$	$\frac{R_m}{\Omega} = \frac{180}{1.67} = \underline{\underline{107.8k}}$

(b) Partial joint penetration groove weld

Base metal value same as in (a)

$$\text{LRFD} = 162k$$

$$\text{ASD} = 107.8k$$

Weld value

Effective throat of weld

$$= \frac{5}{16} - \frac{1}{8} = \frac{3}{16} \text{ in.}$$

$$R_m = (0.60 \times 70) \left(\frac{3}{16} \times 8 \right) = 63k$$

LRFD $\phi = 0.80$	ASD $\Omega = 1.88$
$\phi R_m = (0.80)(63) = \underline{\underline{50.4k}}$	$\frac{R_m}{\Omega} = \frac{63}{1.88} = \underline{\underline{33.5k}}$

\checkmark C.M.E

EXCLUSIVE: Just in Edutruth only

CHAPTER 15

PROB # 15-1

Beam is a W18X55 ($t_w = 0.390$ in.)

Bolt and angle available strength

LRFD	ASD
$\phi R_m = 126 \text{ k}$	$\frac{R_m}{\Omega} = 83.9 \text{ k}$

Beam web available strength

LRFD	ASD
$\phi V_m = (0.390)(351) = 136.9 \text{ k}$	$\frac{V_m}{\Omega} = (0.390)(234) = 91.26 \text{ k}$

ANSWERS.

126 k LRFD

83.9 k ASD

✓ GME

PROB # 15-2

Beam is a W18X55 ($t_w = 0.390$ in.)

Bolt and angle available strength

LRFD	ASD
$\phi R_m = 122 \text{ k}$	$\frac{R_m}{\Omega} = 81.6 \text{ k}$

Beam web available strength

LRFD	ASD
$\phi V_m = (0.390)(410) = 159.9 \text{ k}$	$\frac{V_m}{\Omega} = (0.390)(273) = 106.47 \text{ k}$

ANSWERS.

122 k LRFD

81.6 k ASD

✓ GME

EXCLUSIVE: Just in Edutruth only

PROB #15-3

Beam is a W18x55 ($t_w = 0.390$ in.)

Bolt and angle available strength

LRFD	ASD
$\phi R_m = 114 \text{ k}$	$\frac{R_m}{\Omega} = 76.1 \text{ k}$

Beam web available strength

LRFD	ASD
$\phi V_m = (0.390)(457) = 178.23 \text{ k}$	$\frac{V_m}{\Omega} = (0.390)(305) = 118.95 \text{ k}$

ANSWERS.

114 k LRFD

76.1 k ASD

✓ CMC

EXCLUSIVE: Just in Edutruth only

PROB #15-4

LRFD	ASD
$R_u = (1.2)(75) + (1.6)(50) = 170 \text{ k}$	$R_a = 75 + 50 = 125 \text{ k}$

USE 6 Row Connection

Bolt and angle available strength

LRFD	ASD
$\phi R_m = 222 \text{ k} > 170 \text{ k} \quad \text{OK}$	$\frac{R_m}{\Omega} = 148 \text{ k} > 125 \text{ k} \quad \text{OK}$

Beam web available strength

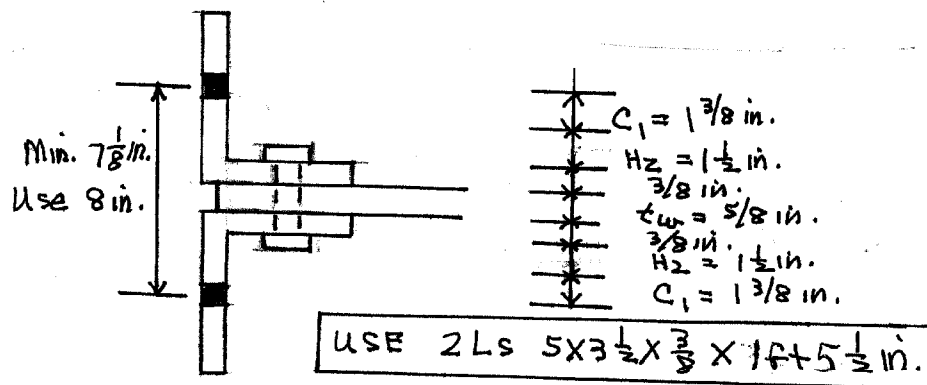
LRFD	ASD
$\phi V_m = (0.605)(614) = 371.47 \text{ k} > 170 \text{ k}$	$\frac{V_m}{\Omega} = (0.605)(409) = 247.44 \text{ k} > 125 \text{ k}$

Select angle sizes

$$\text{Length} = (5)(3) + (2)(1\frac{1}{4}) = 17\frac{1}{2} \text{ in. ok for } T = 29\frac{5}{8} \text{ in.}$$

Leg sizes obtained by referring to AISC Table 7-16.

$$\text{Legs bolted to web} = 2\frac{1}{2} + 1 = 3\frac{1}{2} \text{ in.}$$



v g c m c

EXCLUSIVE: Just in Edutruth only

PROB #15-5

LRFD	ASD
$R_u = (1.2)(75) + (1.6)(50) = 170k$	$R_a = 75 + 50 = 125k$

Use 6 Row Connection

Bolt and angle available strength

LRFD	ASD
$\phi R_m = 210k > 170k$ <u>OK</u>	$\frac{R_m}{\Omega} = 140k > 125k$ <u>OK</u>

Beam web available strength

LRFD	ASD
$\phi V_m = (0.605)(684) = 413.8k > 170k$	$\frac{V_m}{\Omega} = (0.605)(456) = 275.9k > 125k$

Select angle sizes

$$\text{Length} = (5)(3) + (2)\left(1\frac{1}{4}\right) = 17\frac{1}{2}" \text{ OK for } T = 29\frac{5}{8} \text{ in.}$$

Leg sizes obtained by referring to AISC Table 7-16.

$$\text{Legs bolted to web} = 2\frac{1}{2} + 1 = 3\frac{1}{2} \text{ in.}$$

O.S. legs 4 in.

USE A SIX ROW CONNECTION (1-in. A325N)
WITH 2 Ls $4 \times 3\frac{1}{2} \times \frac{3}{8} \times 17\frac{1}{2}$ in.

✓ gmc

EXCLUSIVE: Just in Edutruth only

EXCLUSIVE: Just in Edutruth only <http://edutruth.4shared.com>

EXCLUSIVE: Just in Edutruth only

PROB#15-6

Beam is a W18X55 ($t_w = 0.390$ in.) and
girder is a W30X90 ($t_w = 0.470$ in.)

LRFD	ASD
$\phi R_m = 88.6 k$	$\frac{R_m}{\Omega} = 59.1 k$

Beam web design strength

LRFD	ASD
$\phi V_m = (0.39)(351) = 136.9 k$	$\frac{V_m}{\Omega} = (0.39)(234) = 91.2 k$

Girder web strength

LRFD	ASD
$\phi V_m = (2)(0.47)(351) = 329.9 k$	$\frac{V_m}{\Omega} = (2)(0.47)(234) = 220 k$

ANSWERS.

LRFD 88.6 k	ASD 59.1 k
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✓ gcm

EXCLUSIVE: Just in Edutruth only

PROB #15-7

Beam is a W27X84 ($t_w = 0.460$ in.) and girder is a W30X116 ($t_w = 0.565$ in.)

Reactions to be transferred

LRFD	ASD
$R_u = (1.2)(50) + (1.6)(60) = 156 \text{ k}$	$R_a = 50 + 60 = 110 \text{ k}$

Try a 5 Row Connection

Bolt and angle available strength

LRFD	ASD
$\phi R_m = 174 \text{ k} > 156 \text{ k} \quad \text{OK}$	$\frac{R_m}{\Omega} = 116 \text{ k} > 110 \text{ k} \quad \text{OK}$

Beam web available strength

LRFD	ASD
$\phi V_m = (0.460)(570) = 262 \text{ k} > 156 \text{ k}$	$\frac{V_m}{\Omega} = (0.460)(380) = 174.8 \text{ k} > 110 \text{ k}$

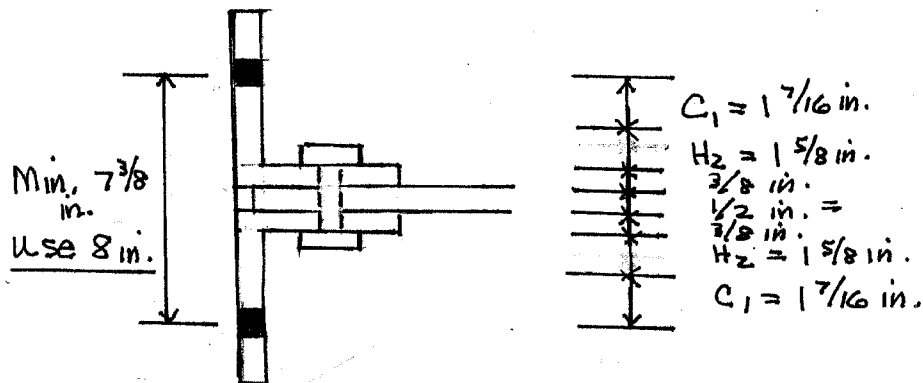
✓ OK

EXCLUSIVE: Just in Edutruth only

PROB#15-7 CONTD.

Girder web available strengths

LRFD	ASD
$\phi V_n = (2)(0.565)(570) = 644.1 \text{ k} > 152 \text{ k}$	$\frac{V_n}{\Omega} = (2)(0.565)(380) = 429.4 \text{ k} > 110 \text{ k}$



USE 5 Row connection with
2 Ls $5 \times 3\frac{1}{2} \times \frac{3}{8} \times 1 \text{ ft} - 2\frac{1}{2}$ in.

✓ gcm

416

EXCLUSIVE: Just in Edutruth only

PROB# 15-8

Beam is a W18x55 ($t_w = 0.390$ in.) and girder is a W30x90 ($t_w = 0.470$ in.)

LRFD	ASD
$\phi R_m = 137k$	$\frac{R_m}{\Omega} = 91.4k$

Beam web available strength

LRFD	ASD
$\phi V_m = (0.390)(457) = 178.2k$	$\frac{V_m}{\Omega} = (0.390)(305) = 118.9k$

Girder web design strength

LRFD	ASD
$\phi V_m = (2)(0.470)(457) = 429.6k$	$\frac{R_m}{\Omega} = (2)(0.470)$

ANSWRS,

137k LRFD	91.4k ASD
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✓ gcm

417

EXCLUSIVE: Just in Edutruth only

PROB # 15-9

Beam is a W18X50 ($t_w = 0.355 \text{ in.}$) and
girder is a W27X146 ($t_w = 0.605 \text{ in.}$)

LRFD	ASD
$R_u = (1.2)(30) + (1.6)(20) = 68 \text{ k}$	$R_a = 30 + 20 = 50 \text{ k}$

Try a 3-Row Connection with $\frac{1}{4}$ in. angle t

LRFD	ASD
$\phi R_m = 71.8 \text{ k} > 68 \text{ k} \quad \underline{\text{OK}}$	$\frac{R_m}{2} = 47.9 \text{ k} < 50 \text{ k} \quad \underline{\text{N.G.}}$

Beam web design strength

LRFD	ASD
$\phi R_m = (0.355)(163) = 57.9 \text{ k} < 68 \text{ k} \quad \underline{\text{N.G.}}$	$\frac{R_m}{2} = (0.355)(109) = 38.7 \text{ k} < 50 \text{ k} \quad \underline{\text{N.G.}}$

Try a 4-Row Connection with $\frac{1}{4}$ -in. angle t

LRFD	ASD
$\phi R_m = 97.9 \text{ k} > 68 \text{ k} \quad \underline{\text{OK}}$	$\frac{R_m}{2} = 65.3 \text{ k} > 50 \text{ k} \quad \underline{\text{OK}}$

418

EXCLUSIVE: Just in Edutruth only

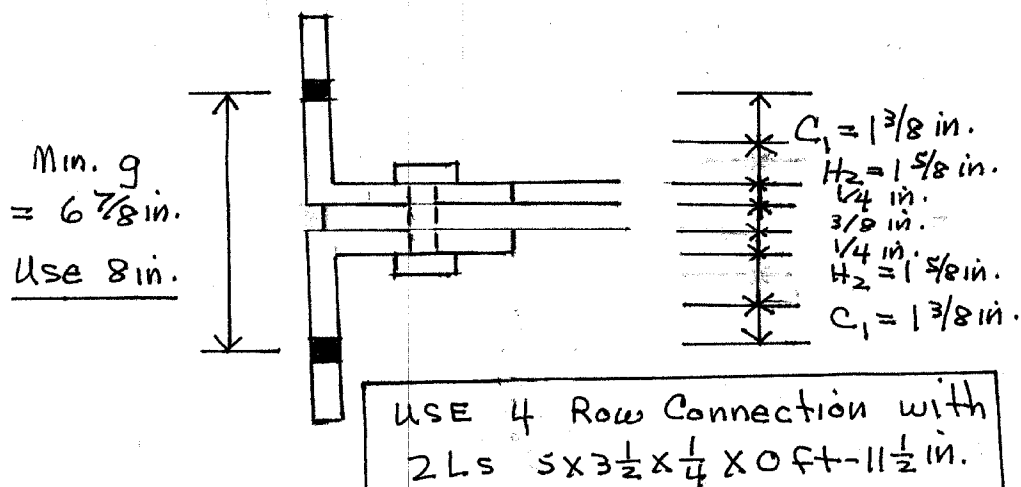
PROB#15-9 CONTD.

Beam web design strength

LRFD	ASD
$\phi R_m = (0.755)(222) = 78.8 \text{ k} > 68 \text{ k} \text{ OK}$	$\frac{R_m}{\Omega} = (0.755)(148) = 52.5 \text{ k} > 50 \text{ k} \text{ OK}$

Girder web design strength

LRFD	ASD
$\phi R_m = (2)(0.605)(222) = 268.6 \text{ k} > 68 \text{ k} \text{ OK}$	$\frac{R_m}{\Omega} = (2)(0.605)(148) = 179.1 \text{ k} > 50 \text{ k} \text{ OK}$



v gmc

EXCLUSIVE: Just in Edutruth only

PROB #15-10

Beam is a W27X84 ($t_w = 0.460$ in.) and
girder is a W30X116 ($t_w = 0.565$ in.)

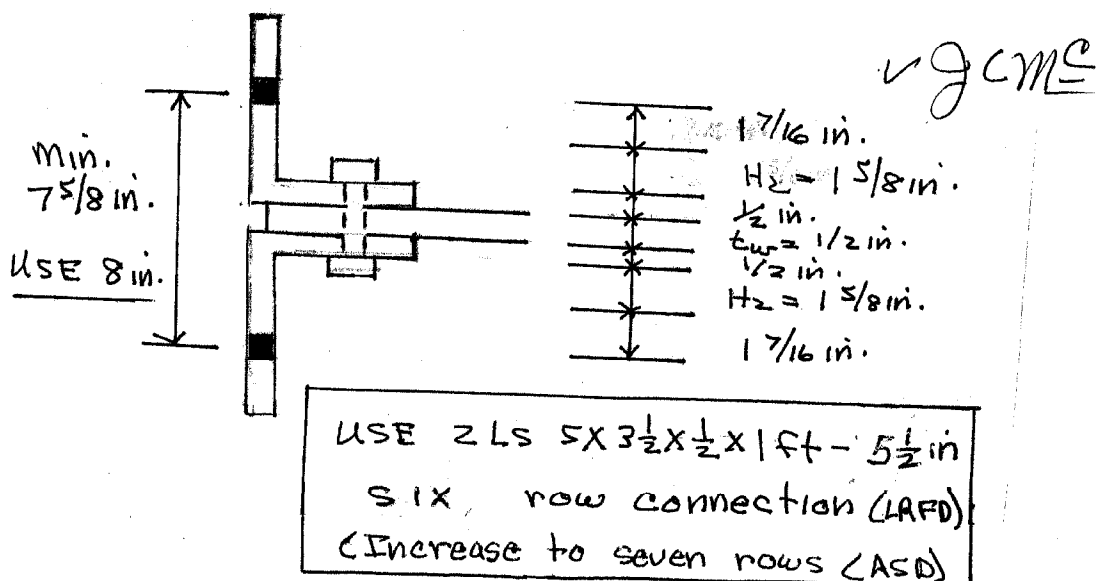
LRFD	ASD
$R_u = (1.2)(80) + (1.6)(110) = 272 \text{ k}$	$R_a = 80 + 110 = 190 \text{ k}$

Try 6-row Connection with $\frac{1}{2}$ in. angle

LRFD	ASD
$\phi R_n = 281 \text{ k} > 272 \text{ k}$	$\frac{R_n}{\Omega} = 187 \text{ k} < 190 \text{ k}$

Beam web design strength

LRFD	ASD
$\phi V_n = (0.565)(684) = 386.5 \text{ k} > 272 \text{ k} \text{ ok}$	$\frac{V_n}{\Omega} = (0.565)(456) = 257.6 \text{ k} > 190 \text{ k} \text{ ok}$



EXCLUSIVE: Just in Edutruth only

PROB #15-11

Beam is a W33X130 ($t_w = 0.580$ in.) and column is a W36X150 ($t_c = 0.940$ in.)

LRFD	ASD
$R_u = (1.2 \times 60) + (1.6 \times 80) = 200 \text{ k}$	$R_a = 60 + 80 = 140 \text{ k}$

From AISC Table 10-2 try $\frac{1}{4}$ -in. weld ($L = 20\frac{1}{2}$ in.)
 $n = 7$ rows, Min web $t = 0.381$ in. < 0.580 in. OK

LRFD	ASD
$\phi R_m = 304 \text{ k} > 200 \text{ k} \text{ OK}$	$\frac{R_m}{\Omega} = 202 \text{ k} > 140 \text{ k} \text{ OK}$

with $\frac{5}{16}$ -in. angle

LRFD	ASD
$\phi R_m \text{ for bolts} = 215 \text{ k} > 200 \text{ k} \text{ OK}$	$\frac{R_m}{\Omega} = 144 \text{ k} > 140 \text{ k} \text{ OK}$

checking column flange

LRFD	
$\phi R_m = (2 \times 0.940)(717) = 1348 \text{ k} > 200 \text{ k} \text{ OK}$	$\frac{R_m}{\Omega} = (2 \times 0.940)(478) = 898.68 > 140 \text{ k} \text{ OK}$

WJCMC

EXCLUSIVE: Just in Edutruth only

PROB# 15-12

Beam is a W33X130 ($t_w = 0.580$ in.) and
column is a W36X150 ($t_c = 0.940$ in.)

Reactions

LRFD	ASD
$R_u = (1.2)(60) + (1.6)(80) = 200k$	$R_a = 60 + 80 = 140k$

From AISC Table 10-3 try 22-in. long $\frac{3}{16}$ -in.
weld A ($\min t_w = 0.286$ in. < 0.580 in. OK)

LRFD	ASD
$\phi R_n = 241k > 200k$ <u>OK</u>	$\frac{R_n}{2} = 160k > 140k$ <u>OK</u>

From same AISC table try $\frac{1}{4}$ -in. weld B (\min
 $t_c = 0.19$ in. < 0.940 in. OK)

LRFD	ASD
$\phi R_n = 205k > 200k$ <u>OK</u>	$\frac{R_n}{2} = 137k < 140k$ <u>N.G.</u>

ANSWERS,

Use 2LS 4X3 X $\frac{5}{16}$ X 10 in, weld A $\frac{3}{16}$ in, weld B $\frac{1}{4}$ in.
For LRFD

Use 2LS 4X3 X $\frac{3}{8}$ X 10 in, weld A $\frac{3}{16}$ in, weld B $\frac{5}{16}$ in.
For ASD

vgm

422

EXCLUSIVE: Just in Edutruth only

PROB #15-13

Beam is a W30 x 124 ($t_w = 0.585$ in.) and column is a W14 x 145 ($t_f = 1.09$ in.)

LRFD	ASD
$R_u = (1.2)(60) + (1.6)(80) = 200k$	$R_a = 60 + 80 = 140k$

Design of weld A

From AISC Table 10-3 try $\frac{3}{16}$ in. weld A 20 in. long, Min. web t for beam = 0.286 in. < 0.585 in.

LRFD	ASD
$\phi R_n = 223k > 200k$ <u>OK</u>	$\frac{R_n}{\Omega} = 149k > 140k$ <u>OK</u>

Design of weld B

From AISC Table 10-3 try $\frac{5}{16}$ in. weld B 20 in. long, min. Flange $t = 0.238$ in. < 1.09 in. OK

LRFD	ASD
$\phi R_n = 226k > 200k$ <u>OK</u>	$\frac{R_n}{\Omega} = 151k > 140k$ <u>OK</u>

ANSWERS.

Use 2Ls 4x3x $\frac{3}{8}$ x 1 ft - 8 in (weld A = $\frac{3}{16}$ in, weld B = $\frac{5}{16}$ in.) LRFD & ASD

✓ gmc

EXCLUSIVE: Just in Edutruth only

PROB # 15-14

Beam is a W30X124 ($t_w = 0.585$ in.) and column is a W14X145 ($t_c = 1.09$ in.)

LRFD	ASD
$R_u = (1.2)(90) + (1.6)(100) = 268 \text{ k}$	$R_a = 90 + 100 = 190 \text{ k}$

Design of weld A

From AISC Table 10-3 try $\frac{1}{4}$ -in. weld A 22 in.
long. Min. t_w for beam = 0.381 in. < 0.585 in. OK

LRFD	ASD
$\phi R_m = 321 \text{ k} > 268 \text{ k} \quad \underline{\text{OK}}$	$\frac{R_m}{\Omega} = 214 \text{ k} > 190 \text{ k} \quad \underline{\text{OK}}$

Design of weld B

From AISC Table 10-3 try $\frac{3}{8}$ -in. weld B 22 in.
long. Min. t_c for column = 0.286 in. < 1.09 in. OK

LRFD	ASD
$\phi R_m = 308 \text{ k} > 268 \text{ k} \quad \underline{\text{OK}}$	$\frac{R_m}{\Omega} = 205 \text{ k} > 190 \text{ k} \quad \underline{\text{OK}}$

ANSWERS

Use 2LS 4X3 X $\frac{7}{16}$ X 10 in.
LRFD & ASD
 $\frac{1}{4}$ in. weld A, $\frac{3}{8}$ in. weld B

v gmc

EXCLUSIVE: Just in Edutruth only

PROB#15-15

Beam is W16X67 ($t_w = 0.395 \text{ in.}$), $d = 16.3 \text{ in.}$, $t_f = 0.665 \text{ in.}$,
 $L = 1.07 \text{ in.}$

Column is W14X92 ($t_w = 0.510 \text{ in.}$)

LRFD	ASD
$R_u = (1.2)(25) + (1.6)(30) = 78 \text{ k}$	$R_a = 25 + 30 = 55 \text{ k}$

For local web yielding

$N_{min} = \frac{R_u - \phi R_1}{\phi R_2} \geq L$. The values of ϕR_1 , ϕR_2 , etc. are taken from AISC Table 9-4.

$$N_{min} = \frac{78 - 52.7}{19.8} = 1.28 \text{ in.}$$

For web crippling

When $\frac{N}{d} \leq 0.2$

$$N_{min} = \frac{R_u - \phi R_3}{\phi R_4} = \frac{78 - 73.1}{6.15} = 0.80 \text{ in.}$$

When $\frac{N}{d} > 0.2$

$$N_{min} = \frac{R_u - \phi R_5}{\phi R_6} = \frac{78 - 66.7}{8.20} = 1.38 \text{ in.}$$

Thus $N_{min} = 1$


From AISC Table 10-5 an 8-in. angle length with a $\frac{3}{4}$ -in. thickness and a $3\frac{1}{2}$ in. min. O.S. leg will prevail

$$\phi R_n = 117 \text{ k} > 78 \text{ k} \quad \underline{\underline{OK}}$$

EXCLUSIVE: Just in Edutruth only

PROB #15-15 CONTD.

Try $1L 6 \times 4 \times \frac{3}{4}$, 8 in. long with $5\frac{1}{2}$ in. bolt gage

For $\frac{7}{8}$ -in. diameter A325-N bolts a connection
with 4 bolts  (Type B AISC Fig 10-7a)
will provide:

LRFD	ASD
$\phi R_m = 130k > 78k$ <u>ok</u>	$\frac{R_m}{\Omega} = 86.6k > 55k$

\checkmark gcm^c

EXCLUSIVE: Just in Edutruth only

PROB #15-16

Using a W24X76 ($d = 23.9$ in., $t_w = 0.440$ in., $b_f = 8.99$ in.,
 $t_f = 0.680$ in., $T = 20\frac{3}{4}$ in.)

(a) Design of moment welds

LRFD	ASD
$R_u = (1.2 \times 40) + (1.6 \times 70) = 160 \text{ k}$ $M_u = (1.2 \times 75) + (1.6 \times 100) = 250 \text{ ft-k}$ $T_u = C_u = \frac{(1.2)(250)}{23.9 - 0.68} = 129.2 \text{ k}$	$R_a = 40 + 70 = 110 \text{ k}$ $M_a = 75 + 100 = 175 \text{ ft-k}$ $T_a = C_a = \frac{(1.2)(175)}{23.9 - 0.680} = 90.44 \text{ k}$

R_m per in. of weld with $t_f = 0.680$ in. for full penetration groove weld (F_y of base metal = 36 ksi)
 $= F_y A_w = (36)(1 \times 0.680) = 24.48 \text{ k/in. of weld}$

LRFD $\phi = 0.9$	ASD $\Omega = 1.67$
$\phi R_m = (0.9)(24.48) = 22.03 \text{ k/in.}$ Req'd A for groove weld $= \frac{T_u}{\phi R_m} = \frac{129.2}{22.03} = 5.86 \text{ in.} < b_f$ USE 6 in. wide E70 full penetration groove weld (3 in. on each side of web)	$\frac{R_m}{\Omega} = \frac{24.48}{1.67} = 14.66 \text{ k/in.}$ Req'd A for groove weld $= \frac{T_a}{\frac{R_m}{\Omega}} = \frac{90.44}{14.66} = 6.17 \text{ in.} < b_f$ USE 6½ in. wide E70 full penetration groove weld (3 in. on each side of web)

427

EXCLUSIVE: Just in Edutruth only

PROB #15-16 CONTD.

(b) Design of shear welds

Try $\frac{5}{16}$ in. fillet welds on clip angles

$$R_n \text{ of weld per in} = F_w A_w$$

$$= (0.6)(70)\left(\frac{5}{16} \times 0.707\right) = 9.28 \text{ k/in.}$$

LRFD $\phi = 0.75$	ASD $\Omega = 2.00$
$\phi R_n = (0.75)(9.28) = 6.96 \text{ k/in.}$ weld length reqd on each side $= \frac{160/2}{6.96} = 11.49 \text{ in.}$ USE $11\frac{1}{2} \text{ in.}$ (OK for T of beam of $20\frac{3}{4} \text{ in.}$	$\frac{R_n}{\Omega} = \frac{9.28}{2.00} = 4.64 \text{ k/in.}$ weld length reqd on each side $= \frac{119/2}{4.64} = 11.85 \text{ in.}$ USE <u>12 in.</u> (OK for T of beam of $20\frac{3}{4} \text{ in.}$)

v gcm

EXCLUSIVE: Just in Edutruth only

PROB # 15-17

LRFD	ASD
$w_u = (1.2)(1.5) + (1.6)(2) = 5.0 \text{ k/ft}$	$w_a = 1.5 + 2 = 3.5 \text{ k/ft}$
$M_u = \frac{(5.0)(30)^2}{12} = 375 \text{ ft-k}$	$M_a = \frac{(3.5)(30)^2}{12} = 262.5 \text{ ft-k}$
$V_u = \left(\frac{30}{2}\right)(5) = 75 \text{ k}$	$V_a = \left(\frac{30}{2}\right)(3.5) = 52.5 \text{ k}$

(a) Select section

From AISC Table 3-2 try a W21x48

LRFD	ASD
$\phi_b M_{px} = 398 \text{ ft-k} > 375 \text{ ft-k} \text{ OK}$	$\frac{M_{px}}{\Omega_b} = 265 \text{ ft-k} > 262.5 \text{ ft-k} \text{ OK}$

(b) Design of shear welds

Try $\frac{3}{16}$ -in. fillet welds on clip angles

$$R_m \text{ of weld per inch} = F_w A_w$$

$$= (0.6)(70) \left(\frac{3}{16} \times 0.707 \right) = 5.57 \text{ k/in.}$$

LRFD	ASD
$\phi R_m = (0.75)(5.57) = 4.18 \text{ k/in.}$ weld length reqd. ea. side $= \frac{75/2}{4.18} = 8.97 \text{ in.}$ <div style="border: 1px solid black; padding: 2px; display: inline-block;">Use 9 in. weld ea. side</div>	$\frac{R_m}{\Omega} = \frac{5.57}{2.00} = 2.78 \text{ k/in.}$ weld length reqd. ea. side $= \frac{52.5/2}{2.78} = 9.44 \text{ in.}$ <div style="border: 1px solid black; padding: 2px; display: inline-block;">Use $9\frac{1}{2}$ in. weld ea. side</div>

EXCLUSIVE: Just in Edutruth only

PROB # 15-17 CONTD.

(c) Design of moment welds

using a W21x48 ($d = 20.6$ in., $t_f = 0.430$ in.,
 $b_f = 8.14$ in., $r = 18\frac{3}{8}$ in.)

R_m per in. of weld with $t_f = 0.430$ in. for
full penetration groove weld (F_y of base metal = 50 ksi)
 $= F_y A_w = (50)(1 \times 0.430) = 21.5$ k/in. of weld

LRFD	ASD
$\phi R_m = (0.9)(21.5) = 19.35$ k/in. $T_u = C_u = \frac{(12)(375)}{(20.6 - 0.430)} = 223.1$ k Req'd width for groove weld $= \frac{T_u}{\phi R_m} = \frac{223.1}{19.35} = 11.53$ in. > 8.14 in. avail. \therefore Use transfer plate & bottom groove welded to column and fillet welded to W flange of column. see below	$\frac{R_m}{\Omega} = \frac{21.5}{1.67} = 12.87$ k/in. $T_a = C_a = \frac{(12)(262.5)}{(20.6 - 0.430)} = 156.2$ k Req'd width for groove welds $= \frac{T_a}{\frac{R_m}{\Omega}} = \frac{156.2}{12.87} = 12.14$ in. > 8.14 in. avail. Use transfer plate top & bottom groove welded to column and fillet welded to flange of column.

For LRFD assume 1 in. PL each flange

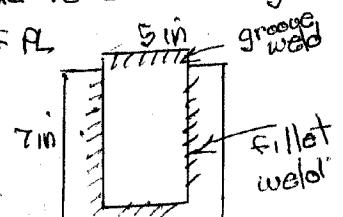
$$T_u = C_u = \frac{(12)(375)}{20.60 + 1.00} = 208.33$$

$$A \text{ of PL} = \frac{208.33}{(0.9)(50)} = 4.63 \text{ in.}^2$$

Use 1x5 PL with full penetration groove weld to column flange

Length of fillet weld on sides and end of PL

$$\text{Assuming } \frac{3}{8} \text{ in.} = \frac{208.33}{(0.6)(70)(\frac{3}{8} \times 20.707)} = 18.71 \text{ in. Say } 19 \text{ in.}$$



EXCLUSIVE: Just in Edutruth only

CHAPTER 16

PROB #16-1

Using a W18x35 ($A_s = 10.3 \text{ in.}^2$, $t_w = 0.300 \text{ in.}$,
 $d = 17.7 \text{ in.}$, $k = 0.827 \text{ in.}$)

$$\frac{h}{t_w} = \frac{17.7 - (2)(0.827)}{0.300} = 53.5 < 3.76 \sqrt{\frac{E}{F_y}} \\ = 3.76 \sqrt{\frac{29 \times 10^3}{50}} = 90.55 \quad \therefore \text{Plastic stress distribution occurs}$$

$$a = \frac{A_s F_y}{0.85 f'_c b_e} = \frac{(10.3)(50)}{(0.85)(3)(84)} = 2.40 \text{ in.}$$

$$M_m = A_s F_y \left(\frac{d}{2} + t - \frac{a}{2} \right) = (10.3)(50) \left(\frac{17.7}{2} + 4 - \frac{2.40}{2} \right) \\ = 6000 \text{ in.} \cdot \text{lb} = 500 \text{ ft} \cdot \text{lb}$$

LRFD $\phi_b = 0.90$	ASD $\Omega_b = 1.67$
$\phi_b M_m = (0.9)(500) = 450 \text{ ft} \cdot \text{lb}$	$\frac{M_m}{\Omega_b} = \frac{500}{1.67} = 299.4 \text{ ft} \cdot \text{lb}$

Checking solution with AISC Table 3-19

$$y_1 = 0$$

$$y_2 = 4 - \frac{2.40}{2} = 2.80 \text{ in.}$$

$$\phi M_m = 428 + \left(\frac{0.3}{0.5} \right) (457 - 428) = 449.4 \text{ ft} \cdot \text{lb} \quad \checkmark$$

$$\frac{M_m}{\phi} = 292 + \left(\frac{0.3}{0.5} \right) (304 - 292) = 299.2 \text{ ft} \cdot \text{lb} \quad \checkmark$$

431

✓ JMC

EXCLUSIVE: Just in Edutruth only

PROB # 16-2

Using a W18x60 ($A_s = 17.6 \text{ in.}^2$, $d = 18.2 \text{ in.}$,
 $b_f = 7.56 \text{ in.}$, $t_f = 0.695 \text{ in.}$)

$$a = \frac{A_s F_y}{0.85 f'_c b_e} = \frac{(17.6)(50)}{(0.85)(3)(84)} = 4.11 \text{ in.} > 4.00 \text{ in.}$$

∴ PNA is located 0.11 in. down in W section

Assuming PNA is at base of steel flange

$$C = (0.85)(3)(84)(4) + (50)(7.56)(0.695) = 1119.5 \text{ k}$$

$$T = (50)(17.6 - 7.56 \times 0.695) = 617.3 \text{ k}$$

Since $C > T$ the PNA falls in the steel flange
 and can be located as follows

$$\bar{y} = \frac{(50)(17.6) - (0.85)(3)(4)(84)}{(2)(50)(7.56)} = 0.03 \text{ in.}$$

$$M_m = [(0.85)(3)(84)(4)(\frac{4}{2} + 0.03)] \\ + (2)(50)(7.56)(0.03)(\frac{0.03}{2}) + (50)(17.6)(\frac{18.2}{2} - 0.03)] \\ = 9738 \text{ in.-k} = 811.5 \text{ ft.-k}$$

LRFD $\phi = 0.90$	ASD $\Omega_b = 1.67$
$\phi M_m = (0.90)(811.5) = 730.3 \text{ ft.-k}$	$\frac{M_m}{\Omega_b} = \frac{811.5}{1.67} = 485.9 \text{ ft.-k}$

Checking solution with AISC Table 3-19

$$y_1 = 0.03$$

$$y_2 = 2.00$$

$$\phi M_m = 735 - \left(\frac{0.03}{0.174}\right)(735 - 715) = 731.6 \text{ ft.-k} \checkmark$$

$$\frac{M_m}{\Omega_b} = 489 - \left(\frac{0.03}{0.174}\right)(489 - 476) = 486.8 \text{ ft.-k} \checkmark$$

432

✓ JCMC

EXCLUSIVE: Just in Edutruth only

PROB # 16-3

Using a W18X60 ($A_s = 17.6 \text{ in}^2$, $d = 18.2 \text{ in.}$)

$$\Sigma Q_m = 486 \text{ k}$$

$$a = \frac{\Sigma Q_m}{0.85 f_c b_e} = \frac{486}{(0.85)(2)(34)} = 2.27 \text{ in.}$$

$$y_2 = 4 - \frac{2.27}{2} = 2.865 \text{ in.}$$

LRFD	ASD
$\phi M_m = 768 + \left(\frac{0.365}{0.500}\right)(801 - 768) = 792.1 \text{ ft-k}$	$\frac{M_m}{\Omega} = 511 + \left(\frac{0.365}{0.500}\right)(532 - 511) = 527.1 \text{ ft-k}$

✓ gcm

EXCLUSIVE: Just in Edutruth only

PROB #16-4

Using a W18x55 ($A_s = 16.2 \text{ in.}^2$, $d = 18.1 \text{ in.}$,
 $b_f = 7.53 \text{ in.}$, $t_f = 0.630 \text{ in.}$)

$$a = \frac{(16.2)(50)}{(0.95)(4)(96)} = 2.48 \text{ in.}$$

$$\begin{aligned} M_n &= A_s F_y \left(\frac{d}{2} + t_f - \frac{a}{2} \right) \\ &= (16.2)(50) \left(\frac{18.1}{2} + 4 - \frac{2.48}{2} \right) \\ &= 9566 \text{ in.-k} = 797.2 \text{ ft-k} \end{aligned}$$

LRFD $\phi = 0.90$	ASD $\Omega = 1.67$
$\phi M_n = (0.90)(797.2) = 717.5 \text{ ft-k}$	$\frac{M_n}{\Omega} = \frac{797.2}{1.67} = 477.4 \text{ ft-k}$

Checking with AISC Table 3-19

$$y_1 = 0$$

$$y_2 = 4 - \frac{2.48}{2} = 2.76 \text{ in.}$$

$$\phi M_n = 702 + \left(\frac{0.26}{0.50} \right) (732 - 702) = 717.6 \text{ ft-k}$$

$$\frac{M_n}{\Omega} = 467 + \left(\frac{0.26}{0.50} \right) (487 - 467) = 477.4 \text{ ft-k}$$

✓ OK

434

EXCLUSIVE: Just in Edutruth only

PROB# 16-5

Using a W16x36 ($A_g = 10.6 \text{ in}^2$, $d = 15.9 \text{ in}$,
 $b_f = 6.99 \text{ in}$, $t_f = 0.430 \text{ in}$.)

$$a = \frac{(10.6)(50)}{(0.85)(4)(96)} = 1.61 \text{ in.}$$

$$M_m = A_g F_y \left(\frac{d}{2} + t_f - \frac{a}{2} \right) = (10.6)(50) \left(\frac{15.9}{2} + 4 - \frac{1.61}{2} \right) \\ = 5907 \text{ in.-k} = 492.2 \text{ ft-k}$$

LRFD $\phi = 0.90$	ASD $\Omega = 1.67$
$\phi M_m = (0.90)(492.2) = 443 \text{ ft-k}$	$\frac{M_m}{\Omega} = \frac{492.2}{1.67} = 294.7 \text{ ft-k}$

Check answers with AISC Table 3-19

$$y_1 = 0$$

$$y_2 = 4 - \frac{1.61}{2} = 3.195$$

$$\phi M_m = 433 + \left(\frac{0.195}{0.50} \right) (453 - 433) = 441 \text{ ft-k}$$

$$\frac{M_m}{\Omega} = 288 + \left(\frac{0.195}{0.50} \right) (301 - 288) = 293.1 \text{ ft-k}$$

✓ JCMC

435

EXCLUSIVE: Just in Edutruth only

PROB# 16-6

Using a W16x31 ($A_s = 9.13 \text{ in.}^2$, $d = 15.9 \text{ in.}$)

$$a = \frac{A_s F_y}{(0.85)(f'_c)(b_e)} = \frac{(9.13)(50)}{(0.85)(14)(72)} = 1.86 \text{ in.}$$

$$M_m = A_s F_y \left(\frac{d}{2} + t - \frac{a}{2} \right) = (9.13)(50) \left(\frac{15.9}{2} + 6.25 - \frac{1.86}{2} \right) \\ = 6057.8 \text{ in.-k} = 504.8 \text{ ft.-k}$$

LRFD $\phi = 0.90$	ASD $\Omega = 1.67$
$\phi M_m = (0.90)(504.8) = 454.3$	$\frac{M_m}{\Omega} = \frac{504.8}{1.67} = 302.3$

ANSWERS.

LRFD 454.3 ft.-k

ASD 302.3 ft.-k

Checking with AISC Table 3-19

$$y_1 = 0$$

$$y_2 = 6.25 - \frac{1.86}{2} = 5.32 \text{ in.}$$

$$\phi M_m = 443 + \left(\frac{0.32}{0.50} \right) (460 - 443) = 453.9 \text{ k} \quad \underline{\text{OK}}$$

$$\frac{M_m}{\Omega} = 295 + \left(\frac{0.32}{0.50} \right) (306 - 295) = 302 \text{ ft.-k} \quad \underline{\text{OK}}$$

✓ gmc

436

EXCLUSIVE: Just in Edutruth only

PROB #16-7

$$a = \frac{\sum Q_m}{0.85 F_c b_e} = \frac{335}{(0.85)(4)(72)} = 1.37 \text{ in.}$$

Using AISC Table 3-19

$$y_1 = 0.220 \text{ in. with above } \sum Q_m \text{ value}$$

$$y_2 = 3.25 + 3.00 - \frac{1.37}{2} = 5.565 \text{ in.}$$

LRFD	ASD
$\phi M_m = 409 + \left(\frac{0.065}{0.50}\right)(421 - 409)$ $= 410.6 \text{ ft-k}$	$\frac{M_m}{\Omega} = 2.72 + \frac{0.065}{0.50}(2.80 - 2.72)$ $= 2.730 \text{ ft-k}$

$\checkmark \phi M_m^c$

437

EXCLUSIVE: Just in Edutruth only

PROB#16-8

(a) select beam section

Assume beam $w_t = 40 \text{ lbs/ft}$

Concrete slab $w_t = \left(\frac{4}{12}\right)(145)(9) = 435 \text{ lbs/ft}$

$w_D = 40 + 435 = 475 \text{ lbs/ft}$

$w_L = (9)(100) = 900 \text{ lbs/ft}$

LRFD	ASD
$w_u = (1.2)(0.475) + (1.6)(0.900) = 2.01 \text{ k/ft}$	$w_a = 0.475 + 0.900 = 1.375 \text{ k/ft}$
$M_u = \frac{(2.01)(38)^2}{8} = 362.8 \text{ ft-k}$	$M_a = \frac{(1.375)(38)^2}{8} = 248.2 \text{ ft-k}$

Effective flange width

$$b_e = (2)\left(\frac{1}{8}\right)(12 \times 38) = 114 \text{ in.}$$

$$b_e = 9 \text{ ft} = 108 \text{ in.} \leftarrow$$

Select W section

$$Y_{\text{conc}} = 4 \text{ in.}$$

Assume $a = 1.25 \text{ in.}$

$$Y_1 = 0$$

$$Y_2 = 4 - \frac{1.25}{2} = 3.375 \text{ in.}$$

Several possibilities are the $W16 \times 31$, $W16 \times 36$, $W16 \times 40$ and the 18×35 .

Try $W16 \times 31$ ($A = 9.13 \text{ in.}^2$)

Going in AISC Table 3-19 to case where Y_1 is the largest possible to provide a $\phi_b M_p =$ about 362.8 ft-k with $Y_2 = 3.375 \text{ in.}$

$$Y_1 = 0.110 \text{ in.}$$

$$\leq \phi_m = 396 \text{ k}$$

$$a = \frac{\leq \phi_m}{0.85 f_b b_e} = \frac{396}{(0.85)(4)(108)} = 1.08 \text{ in.}$$

438

EXCLUSIVE: Just in Edutruth only

PROB #16-8 CONTD.

LRFD	ASD
$\phi M_p = 360 + \left(\frac{0.375}{0.500}\right)(375-360) = 371.25 \text{ k-ft}$ $> 362.8 \text{ ft-k}$	$\frac{M_p}{\Omega_b} = 240 + \left(\frac{0.375}{0.500}\right)(250-240) = 247.5 \text{ ft-k}$ $\approx 248.2 \text{ ft-k}$

(b) Design of studs

Q_n from AISC Table 3-21 = 26.1 k / stud

Total no. of studs needed = $\frac{(2)(396)}{26.1} = 30.34$

USE $31 - \frac{3}{4}$ in. studs

(c) Compute LL service deflection

$C_1 = 161$ from AISC Figure 3-4

$$M_{LL} = \frac{(0.9)(38)^2}{8} = 162.45 \text{ ft-k}$$

I_x = lower bound I from AISC Table 3-20 with

$\gamma_1 = 0.110$ in. and $\gamma_2 = 3$.

$$= 882 + \left(\frac{0.375}{0.500}\right)(930-882) = 918 \text{ in.}^4$$

$$\Delta_{LL} = \frac{M_{LL}^2}{C_1 I_x} = \frac{(162.45)(38)^2}{(161)(918)} = 1.59 \text{ in.} > \left(\frac{1}{360}\right)(38) = 1.27 \text{ in.}$$

Deflection is somewhat I. You may like to increase ^{steel} section size.

(d) Check beam shear

LRFD	ASD
$V_u = (15)(201) = 3015 \text{ k}$ $< \phi V_n = 318 \text{ k}$ <u>OK</u>	$V_a = (15)(1375) = 20625 \text{ k}$ $< \frac{V_n}{\Omega_v} = 28738 \text{ k}$ <u>OK</u>

ANSWERS.

USE W16X31 FOR LRFD & ASD

NOTE: LL DEFLECTIONS HIGH

439

EXCLUSIVE: Just in Edutruth only

PROB # 16-9

(a) Select beam section

$$\text{Assume steel beam wt} = 25 \text{ lbs/ft}$$

$$\text{Concrete slab wt} = \left(\frac{4}{12}\right)(150)(9) = \underline{450}$$

$$w_D = 4 \text{ lbs/ft}$$

$$w_L = (80)(9) = 720 \text{ lbs/ft}$$

LRFD	ASD
$w_u = (1.2)(0.475) + (1.6)(0.720) = 1.722 \text{ k/ft}$	$w_a = 0.475 + 0.720 = 1.195 \text{ k/ft}$
$M_u = \frac{(1.722)(32)^2}{8} = 220.4 \text{ ft-k}$	$M_a = \frac{(1.195)(32)^2}{8} = 152.96 \text{ ft-k}$

Effective flange width

$$b_e = (2)\left(\frac{1}{8}\right)(12 \times 32) = 96 \text{ in.} \leftarrow$$

$$b_e = 9 \text{ ft} = 108 \text{ in.}$$

Select W section

$$Y_{\text{conc.}} = 4 \text{ in.}$$

$$\text{Assume } a = 100 \text{ in.}$$

$$Y_1 = 0$$

$$Y_2 = 4 - \frac{1.00}{2} = 3.50 \text{ in.}$$

From AISC Table 3-19 several sections seem feasible including the W14X22, W12X22 and the W10X26.

Try W14X22 ($A = 6.49 \text{ in.}^2$)

$$\text{Assume } \phi Q_n = A_s F_y = (6.49)(50) = 324.5 \text{ k}$$

$$a_{\text{reqd}} = \frac{\phi Q_n}{0.85 f'_c b_e} = \frac{324.5}{(0.85)(4)(96)} = 0.994 \text{ in.}$$

$$Y_2 = 4 - \frac{0.994}{2} = 3.503 \text{ in.}$$

440

EXCLUSIVE: Just in Edutruth only

PROB#16-9 CONTD.

$\phi_b M_p$ from AISC Table 3-19 = 253 ft-k > 218.1 ft-k

Going to the case where Y_1 is the largest possible to provide a $\phi_b M_p$ about 218.1 ft-k with $Y_2 = 3.503$ in. This occurs when $Y_1 = 0.251$ in.

$$\phi_b M_p = 218 \text{ ft-k} \approx 218.1 \text{ ft-k}$$

$$\leq Q_m \text{ from AISC Table 3-19} = 199k$$

$$a = \frac{199}{(0.85)(4)(96)} = 0.610 \text{ in.}$$

$$Y_2 = 4 - \frac{0.610}{2} = 3.695 \text{ in.}$$

$$\phi_b M_p = 218 + \left(\frac{0.195}{0.50} \right) (226 - 218) = 221.1 \text{ ft-k}$$

$$\frac{M_p}{\Omega_b} = 145 + \left(\frac{0.195}{0.50} \right) (150 - 145) = 147 \text{ ft-k} < 151.04 \text{ ft-k}$$

(b) Design of studs

$$Q_m \text{ for } \frac{3}{4} \text{ in. headed stud (no deck)} = 26.1k \text{ (AISC Table 3-21)}$$

$$\leq Q_m \text{ for W14X22 with } Y_1 = 0.251 \text{ in.} = 199k$$

$$\text{No of studs reqd} = \frac{(199)(2)}{26.1} = 15.25 \text{ Say } \underline{16}$$

(c) Live Load Deflection

$$C_1 = 161 \text{ from AISC Figure 3-4}$$

$$M_{LL} = \frac{(0.720)(32)^2}{8} = 92.16 \text{ ft-k}$$

$$I_x = \text{lower bound } I \text{ from AISC Table 3-20}$$

$$\text{With } Y_1 = 0.251 \text{ in and } Y_2 = 3.695 \text{ in} = 474.5 \text{ in.}^4$$

$$\Delta_{LL} = \frac{M_{LL}^2}{C_1 I_x} = \frac{(92.16)(32)^2}{(161)(474.5)} = 1.24 \text{ in.} > \left(\frac{1}{360} \right) (12 \times 32) = 1.07 \text{ in.}$$

(d) Check Shear

$$V_u = (16)(1.704) = 27.26k < \phi_v V_{nx} = 94.8k \text{ (AISC Table 3-2)}$$

$$V_a = (16)(1.18) = 18.88k < \frac{V_{nx}}{\Omega_v} = 63.2k \text{ (AISC Table 3-2)}$$

USE W14X22 WITH 16 - $\frac{3}{4}$ STUDS LRFD
USE W14X26 FOR ASD

✓ JCM

441

EXCLUSIVE: Just in Edutruth only

PROB #16-10

Assume same work as in Prob #16-9 where a W14x22 was selected

Construction phase check

$$LL = (9)(0.02) = 0.180 \text{ k/ft}$$

$$\text{Concrete} = (9)(\frac{4}{12})(145) = 0.435$$

$$\text{Beam wt} = 0.022$$

Assume fresh concrete (0.435 k/ft) is a LL too

LRFD	ASD
$w_u = (1.2)(0.022) + (1.6)(0.180 + 0.435)$ $= 1.01 \text{ k/ft}$	$w_a = 0.022 + 0.180 + 0.435$ $= 0.637 \text{ k/ft}$
$M_u = \frac{(1.01)(32)^2}{8} = 129.28 \text{ ft-k}$	$M_a = \frac{(0.637)(32)^2}{8} = 81.5 \text{ ft-k}$
$\phi M_n \text{ for W14x22}$ $= 125 \text{ ft-k} < 129.28 \text{ ft-k}$	$\frac{M_n}{\Omega} \text{ for W14x22}$ $= 82.8 \text{ ft-k} > 81.5 \text{ ft-k}$

Checking deflection during construction

$$C_1 = 161$$

$$M = \frac{(0.180 + 0.435 + 0.022)(32)^2}{8} = 81.54 \text{ ft-k}$$

$$I_x \text{ for W14x22} = 199 \text{ in.}^4$$

$$\Delta = \frac{(81.54)(32)^2}{(161)(199)} = \boxed{2.61 \text{ in.}} \text{ - Too High}$$

$$\frac{1}{360} L = \left(\frac{1}{360}\right)(12 \times 32) = 1.07 \text{ in.}$$

✓ OK

442

EXCLUSIVE: Just in Edutruth only

PROB# 16-11

Assume beam wt = 50 lbs/ft

$$\text{Slab wt} = (8.5) \left(\frac{4}{12} \right) (110) = 312 \text{ lbs/ft}$$

$$w_D = 50 + 312 + (8.5)(200) = 2062 \text{ lbs/ft}$$

$$w_L = (8.5)(100) = 850 \text{ lbs/ft}$$

LRFD	ASD
$w_u = (1.2)(2062) + (1.6)(850) = 3834 \text{ lb/ft}$	$w_a = 2062 + 0.850 = 2912 \text{ lb/ft}$
$M_u = \frac{(3834)(38)^2}{8} = 691.3 \text{ ft-k}$	$M_a = \frac{(2912)(38)^2}{8} = 525.6 \text{ ft-k}$

Effective flange width

$$b_e = (2) \left(\frac{1}{8} \times 38 \times 12 \right) = 114 \text{ in.}$$

$$b_e = (12)(8.5) = 102 \text{ in.} \leftarrow$$

(a) Select W section

$$Y_{conc} = 7 \text{ in.}$$

$$\text{Assume } a = 2.2 \text{ in.}$$

$$Y_1 = 0$$

$$Y_2 = 7 - \frac{2.2}{2} = 5.9 \text{ in.}$$

Try W18X46 ($A = 13.5 \text{ in.}^2$, $d = 18.1 \text{ in.}$, $t_w = 0.360 \text{ in.}$)

$$\text{Assume } \phi M_n = F_y A_s = (50)(13.5) = 675 \text{ k}$$

$$a_{reqd} = \frac{675}{(0.85)(3.5)(102)} = 2.22 \text{ in.}$$

$$Y_1 = 0$$

$$Y_2 = 7.0 - \frac{2.22}{2} = 5.89 \text{ in.}$$

Now going to AISC Table 3-19 to case where Y_1 is the largest possible to provide a ϕM_n of about 691.3 ft-k with $Y_2 = 5.89 \text{ in.}$

443

EXCLUSIVE: Just in Edutruth only

PROB #16-11 CONTD.

$$Y_1 = 0.151 \text{ in.}$$

$$\Sigma Q_m = 585 \text{ k}$$

$$a = \frac{585}{(0.85)(3.5)(102)} = 1.93 \text{ in.}$$

$$Y_2 = 7.00 - \frac{1.93}{2.00} = 6.04 \text{ in.}$$

LFRD	ASD
$\phi M_p = 721 + \left(\frac{0.04}{0.85}\right)(743 - 721) = 722.8 \text{ ft-k}$ $> 694.9 \text{ ft-k} \quad \underline{\text{OK}}$	$\frac{M_p}{\Sigma Q} = 480 + \left(\frac{0.04}{0.50}\right)(494 - 480) = 481.1 \text{ ft-k}$ $< 528.4 \text{ ft-k} \quad \underline{\text{N.G.}}$

(b) Design of studs

$$h_r = 3 \text{ in.}$$

$$Q_m \text{ from AISC Table 3-21 for 3.5 ksi concrete}$$

$$= \frac{17.1 + 21.2}{2} = 19.2 \text{ k each}$$

$$\text{No of studs reqd} = \frac{(2)(585)}{19.2} = 60.9$$

USE 61 STUDS

(c) Compute LL Deflection

$$C_1 = 161$$

$$M_{LL} = \frac{(0.85)(38)^2}{8} = 153.4 \text{ ft-k}$$

$$I_x = \text{lower bound } I \text{ from AISC Table 3-20}$$

$$= 2130 + \left(\frac{0.04}{0.50}\right)(2230 - 2130) = 2138 \text{ in}^4$$

$$\Delta_{LL} = \frac{(153.4)(38)^2}{(161)(2138)} = 0.644 \text{ in} < \left(\frac{1}{360}\right)(12 \times 38) = 1.27 \text{ in.}$$

ANSWERS.

USE W18X46
LFRD

USE W18X50
ASD

✓ JCM

444

EXCLUSIVE: Just in Edutruth only

PROB# 16-12

(a) Loads and Moments

LRFD	ASD
$w_u = (1.2)(0.6) + (1.6)(1.25) = 2.72 \text{ k/ft}$	$w_a = 0.6 + 1.25 = 1.85 \text{ k/ft}$
$M_u = \frac{(2.72)(27)^2}{8} = 247.9 \text{ ft-k}$	$M_a = \frac{(1.85)(27)^2}{8} = 168.6 \text{ ft-k}$

Effective flange width b_e

$$b_e = (2)\left(\frac{1}{8}\right)(12 \times 27) = 81 \text{ in.} \leftarrow$$

$$b_e = 10 \text{ ft} = 120 \text{ in.}$$

Select W section

$$Y_{conc} = 4 \text{ in.}$$

$$\text{Assume } a = 1.5 \text{ in.}$$

$$Y_1 = 0$$

$$Y_2 = 4 - \frac{1.5}{2} = 3.25 \text{ in.}$$

$$\text{Try } W14 \times 22 \quad (A = 6.49 \text{ in.}^2)$$

$$\text{Assume } \Sigma Q_m = (6.49)(50) = 324.5 \text{ k}$$

$$\text{The } a_{reqd} = \frac{\Sigma Q_m}{0.85 f_c b_e} = \frac{324.5}{(0.85)(4)(81)} = 1.18 \text{ in.}$$

$$Y_1 = 0$$

$$Y_2 = 4 - \frac{1.18}{2} = 3.41 \text{ in.}$$

LRFD	ASD
$\phi_b M_p$ from AISC Table 3-9 $= 240 + \left(\frac{0.41}{0.50}\right)(253 - 240) = 250.7 \text{ ft-k} > 247.9$	$\frac{M_p}{\Omega_b}$ from AISC Table 3-9 $= 160 + \left(\frac{0.41}{0.50}\right)(168 - 160) = 166.6 \text{ ft-k} < 168.6$

(b) Design of studs

Now going to case where Y_1 is largest possible to provide $\phi_b M_p$ of about 247.9 ft-k. This will occur when $Y_1 = 0$.

$$Y_2 = 4 - \frac{1.18}{2} = 3.41 \text{ in.}$$

$$\Sigma Q_m = 325 \text{ k}$$

445

EXCLUSIVE: Just in Edutruth only

PROB# 16-12 CONTD.

$Q_m = 26.1$ k From AISC Table 3-21

Total number of studs reqd = $\frac{(2)(325)}{26.1} = 24.9$ Say 25

(c) Service live load deflection

$$C_1 = 161$$

$$\text{Service } M_{LL} = \frac{(1.25)(27)^2}{8} = 113.9 \text{ ft-k}$$

$$I_x = \text{lower bound } I = 515 + \left(\frac{0.41}{0.50} \right) (548 - 515) \\ = 542 \text{ in.}^4 \text{ from AISC Table 3-20}$$

$$\Delta_{LL} = \frac{(113.9)(27)^2}{(161)(542)} = 0.951 \text{ in.} > \text{a little larger} \\ \text{than } \frac{1}{360} (12 \times 27) = 0.90 \text{ in.}$$

(d) Check Shear

LRFD	ASD
$V_u = (13.5)(2.72) = 36.72 \text{ k} < \phi_v V_{nx} \\ = 94.8 \text{ k in AISC Table 3-2}$	$V_a = (13.5)(1.85) = 24.9 \text{ k} < \frac{V_{nx}}{\Omega_v} \\ = 63.2 \text{ k in AISC Table 3-2}$

USE W14X22 FOR LRFD AND W14X26 FOR ASD

VGCME

446

EXCLUSIVE: Just in Edutruth only

PROB# 16-13

(a) Loads and Moments

LRFD	ASD
$w_u = (1.2 \times 0.6) + (1.6 \times 1.0) = 2.32 \text{ k/ft}$ $M_u = \frac{(2.32 \times 30)^2}{8} = 261 \text{ ft-k}$	$w_a = 0.6 + 1.00 = 1.60 \text{ k/ft}$ $M_a = \frac{(1.60 \times 30)^2}{8} = 180 \text{ ft-k}$

Effective flange width b_e

$$b_e = (2 \times \frac{1}{8}) (12 \times 30) = 90 \text{ in.} \leftarrow$$

$$b_e = 10 \text{ ft} = 120 \text{ in.}$$

Select W section

$$Y_{conc} = 4 \text{ in.}$$

$$\text{Assume } a = 1.25 \text{ in.}$$

$$Y_1 = 0$$

$$Y_2 = 4 - \frac{1.25}{2} = 3.375 \text{ in.}$$

Severable feasible shapes are available in AISC Table 3-19 including the W12X26, W14X26 and W16X26 sections.

Try W16X26 ($A = 7.68 \text{ in.}^2$)

Going in AISC Table 3-19 to case where Y_1 is largest possible to provide a $\phi_b M_p = \text{about } 261 \text{ ft-k}$ with $Y_2 = 3.375 \text{ in.}$

$$Y_1 = 0.345 \text{ in.}$$

$$\Sigma Q_n = 194 \text{ k}$$

$$a = \frac{\Sigma Q_n}{0.85 f_c b_e} = \frac{194}{(0.85 \times 4) (90)} = 0.634 \text{ in.}$$

$$Y_2 = 4 - \frac{0.634}{2} = 3.68 \text{ in.}$$

$$\phi_b M_p = 275 + \left(\frac{0.18}{0.50} \right) (282 - 275) = 277.5 \text{ ft-k} > 261 \text{ ft-k}$$

$$M_a = 183 + \left(\frac{0.18}{0.50} \right) (188 - 183) = 184.8 \text{ ft-k} > 180 \text{ ft-k}$$

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EXCLUSIVE: Just in Edutruth only

PROB# 16-13 CONTD.

(b) Design of studs

Q_n from AISC Table 3-21 = 26.1 k

$$\text{Total number of studs needed} = \frac{(2)(194)}{26.1} = 14.87$$

USE 15 - $\frac{3}{4}$ in. studs

(c) Compute LL Deflection

$C_1 = 161$ from AISC Figure 3-4

$$M_{LL} = \frac{(1.00)(30)^2}{8} = 112.5 \text{ ft-k}$$

I_x = lower bound moment of inertia

from AISC Table 3-20 with $Y_1 = 3.45 \text{ in}$ and $Y_2 = 3.68 \text{ in}$
 $= 633 + \left(\frac{0.18}{0.50}\right)(663 - 633) = 643.8 \text{ in}^4$

$$\Delta_{LL} = \frac{ML^2}{C_1 I_x} = \frac{(112.5)(30)^2}{(161)(643.8)} = 0.98 \text{ in.} < \left(\frac{1}{360}\right)(12 \times 30) = 1.00 \text{ in.} \quad \underline{\text{OK}}$$

(d) Check beam shear

LRFD	ASD
$V_u = (15)(232) = 34.8 \text{ k}$ $< \phi_v V_{nx} = 106 \text{ k}$ AISC Table 3-2	$V_a = (15)(1.60) = 24 \text{ k}$ $< \frac{V_{nx}}{1.6} = 70.5 \text{ k}$ AISC Table 3-2

USE W 16X26 FOR BOTH LRFD & ASD

✓ JCM

EXCLUSIVE: Just in Edutruth only

PROB#16-14

Loads and Moments

LRFD	ASD
$w_u = (1.2)(0.8) + (1.6)(1.25) = 2.96 \text{ k/ft}$	$w_a = 0.8 + 1.25 = 2.05 \text{ k/ft}$
$M_u = \frac{(2.96)(40)^2}{8} = 592 \text{ ft-k}$	$M_a = \frac{(2.05)(40)^2}{8} = 410 \text{ ft-k}$

Effective Flange width

$$b_e = (2)(\frac{1}{8})(12 \times 40) = 120 \text{ in.}$$

$$b_e = 9 \text{ ft} = (9)(12) = 108 \text{ in.} \leftarrow$$

(a) Select W section

$$Y_{conc} = 4 + 3 = 7 \text{ in.}$$

$$\text{Assume } a = 2 \text{ in.}$$

$$Y_1 = 0$$

$$Y_2 = 7.00 - \frac{2.00}{2} = 6.00 \text{ in.}$$

$$\text{Try } W18 \times 40 (A = 11.8 \text{ in.}^2, d = 17.9 \text{ in.}, I_x = 612 \text{ in.}^4)$$

$$\text{Assume } \phi_b M_n = A_s F_y = (11.8)(50) = 590 \text{ k}$$

$$a_{reqd} = \frac{\phi_b M_n}{0.85 f'_c b_e} = \frac{590}{(0.85)(4)(108)} = 1.607 \text{ in.}$$

$$Y_1 = 0$$

$$Y_2 = 7 - \frac{1.607}{2} = 6.20 \text{ in.}$$

LRFD	ASD
$\phi_b M_p = 659 + \left(\frac{0.20}{0.50}\right)(681 - 659)$ $= 667.8 \text{ ft-k} > 592 \text{ ft-k}$	$\frac{M_p}{\Omega_b} = 439 + \left(\frac{0.20}{0.50}\right)(453 - 439)$ $= 444.6 \text{ ft-k} > 410 \text{ ft-k}$

Check Δ of beam due to conc. + steel beam wt

$$w_t = (9)(\frac{4}{12})(110) + 40 = 370 \text{ lbs/ft}$$

$$M = \frac{(0.370)(40)^2}{8} = 74 \text{ ft-k}$$

$$C_1 = 161$$

$$\Delta = \frac{(74)(40)^2}{(161)(612)} = 1.20 \text{ in.} < 2.50 \text{ in.} \quad \text{OK}$$

449

EXCLUSIVE: Just in Edutruth only

PROB #16-14 CONTD.

Going to largest γ_1 in Manual Table 5-14 such that a $\phi_b M_p$ of about 592 ft-k is provided, say $\gamma_1 = 0.263$ and $\Sigma Q_m = 430$ k.

$$a = \frac{430}{(0.85)(4)(108)} = 1.171 \text{ in.}$$

$$\gamma_2 = 7.000 - \frac{1.171}{2.00} = 6.414 \text{ in.}$$

LRFD	ASD
$\phi_b M_p = 587 + \left(\frac{0.414}{0.500}\right)(603 - 587) = 600.2 \text{ ft-k} > 592 \text{ ft-k}$	$\frac{M_p}{\gamma_b} = 390 + \left(\frac{0.414}{0.500}\right)(401 - 390) = 399.1 \text{ ft-k} < 410 \text{ ft-k}$ <u>N.G.</u>

(b) Design of Studs

Q_m from AISC Table 3-21 = 17.2 k

$$\text{No of studs reqd} = \frac{(2)(430)}{17.2} = \underline{\underline{50}}$$

(c) Determine service LL deflection

$$M_{LL} = \frac{(1.25)(40)^2}{8} = 250 \text{ ft-k}$$

$$C_1 = 161$$

$$I_x = \text{lower bound } I = 1720 + \left(\frac{0.414}{0.500}\right)(1800 - 1720) = 1786.2 \text{ in.}^4$$

$$\Delta_{LL} = \frac{(250)(40)^2}{(161)(1786.2)} = 1.39 \text{ in.} > \left(\frac{1}{360}\right)(12 \times 40) = 1.33 \text{ in.} \text{ (a little high)}$$

(d) Check beam shear

LRFD	ASD
$V_u = (20)(2.96) = 59.2 \text{ k}$ $< \phi_v V_{mx} = 169 \text{ k}$ <u>OK</u>	$V_a = (20)(2.05) = 41 \text{ k}$ $< \frac{V_{mx}}{\Omega_v} = 113 \text{ k}$

ANSWRS.

USE W18X40 WITH 50 STUDS FOR LRFD
USE W18X40 WITH 60 STUDS FOR ASD

✓ JCM

450

EXCLUSIVE: Just in Edutruth only

PROB #16-15

Loads and Moments

LRFD	ASD
$w_u = (1.2)(0.8) + (1.6)(1.25) = 2.96 \text{ k/ft}$	$w_a = 0.8 + 1.25 = 2.05 \text{ k/ft}$
$M_u = \frac{(2.96)(44)^2}{8} = 716.3 \text{ ft-k}$	$M_a = \frac{(2.05)(44)^2}{8} = 496.1 \text{ ft-k}$

Effective Flange widths

$$b_e = (2)\left(\frac{1}{8}\right)(12 \times 44) = 132 \text{ in.}$$

$$b_e = 9 \text{ ft} = 108 \text{ in.} \leftarrow$$

Select W section

$$Y_{conc} = 4 + 3 = 7 \text{ in.}$$

$$\text{Assume } a = 1.60 \text{ in.}$$

$$Y_1 = 0$$

$$Y_2 = 7 - \frac{1.60}{2} = 6.20 \text{ in.}$$

$$\text{Try } W21 \times 44 \text{ (} A = 13.0 \text{ in.}^2, d = 20.7 \text{ in.)}$$

$$\text{Assume } \phi Q_n = A_s F_y = (13.0)(60) = 650 \text{ k}$$

$$a = \frac{650}{(0.85)(4)(108)} = 1.77 \text{ in.}$$

$$Y_1 = 0$$

$$Y_2 = 7 - \frac{1.77}{2} = 6.115 \text{ in.}$$

LRFD	ASD
$\phi_b M_p = 795 + \left(\frac{0.115}{0.500}\right)(819 - 795)$ $= 800.5 \text{ ft-k} > 716.3 \text{ ft-k} \checkmark$	$\frac{M_p}{\Omega_b} = 529 + \left(\frac{0.115}{0.500}\right)(543 - 529)$ $= 532.7 \text{ ft-k} > 496.1 \text{ ft-k} \checkmark$

Going to largest Y_1 such that $\phi_b M_p$ of about 716.3 ft-k is provided with $Y_2 = 6.115 \text{ in.}$

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EXCLUSIVE: Just in Edutruth only

PROB #16-15 CONTD.

$$Y1 = 0.225 \text{ in.}$$

$$\leq Q_m = 503 \text{ k}$$

$$a = \frac{503}{(0.85)(4)(108)} = 1.37 \text{ in.}$$

$$Y2 = 7.00 - \frac{1.37}{2} = 6.315 \text{ in}$$

LRFD	ASD
$\phi_b M_p = 728 + \left(\frac{0.315}{0.50}\right)(247 - 728)$ $= 740 \text{ ft-k} > 716.3 \text{ ft-k} \text{ OK}$	$\frac{M_p}{\Omega_b} = 484 + \left(\frac{0.315}{0.50}\right)(497 - 484)$ $= 492 \text{ ft-k} < 496.1 \text{ ft-k} \text{ OK}$

Design of Studs

$$h_2 = 3 \text{ in.}$$

Assume $H_s = 50$

Assume 1 stud in a rib @ beam intersection = N_2

$$w_{r2} = 6 \text{ in.}$$

$Q_m = 21.2 \text{ k}$ from AISC Table 3-21 (assuming)

$$\text{No of studs reqd} = \frac{(2)(503)}{21.2} = 47.45 \text{ USE 48 STUDS}$$

For ASD it is necessary to go to $Y2 = 0.113 \text{ in.}$

$$\leq Q_m = 576 \text{ k and } \frac{2 \times 576}{21.2} = 54.3 \text{ Say 55 STUDS}$$

Compute LL Deflection

$$C_1 = 161$$

$$M_{LL} = \frac{(1.25)(44)^2}{8} = 302.5 \text{ ft-k}$$

$$I_x = \text{lower bound } I = 2350 + \left(\frac{0.315}{0.50}\right)(2450 - 2350) = 2413 \text{ in}^4$$

$$\Delta_{LL} = \frac{(302.5)(44)^2}{(161)(2413)} = 1.51 \text{ in.} > \left(\frac{1}{360}\right)(12 \times 44) = 1.47 \text{ in.} \text{ OK}$$

Check Beam Shear

LRFD	ASD
$V_u = (22)(2.96) = 65.12 \text{ k}$ $\leq \phi V_{mx} = 217.8 \text{ OK}$	$V_a = (22)(2.05) = 45.1 \text{ k}$ $< \frac{V_{mx}}{\Omega_x} = 145.8 \text{ OK}$

ANSWERS.

USE W21X44 WITH
48 STUDS LRFD

USE W21X44 WITH
55 STUDS ASD

452

✓ 9 CM

EXCLUSIVE: Just in Edutruth only

PROB # 16-16

Loads and moments

LFRD	ASD
$w_u = (1.2)(0.8) + (1.6)(1.25) = 2.96 \text{ k/ft}$	$w_a = 0.8 + 1.25 = 2.05 \text{ k/ft}$
$M_u = \frac{(2.96)(34)^2}{8} = 427.7 \text{ ft-k}$	$M_a = \frac{(2.05)(34)^2}{8} = 296.2 \text{ ft-k}$

Effective flange widths

$$b_e = (2)(\frac{1}{8})(12 \times 34) = 102 \text{ in.} \leftarrow$$

$$b_e = 9 \text{ ft} = 108 \text{ in.}$$

Select W section

$$Y_{conc} = 4 + 3 = 7 \text{ in.}$$

$$\text{Assume } a = 2 \text{ in.}$$

$$Y_1 = 0$$

$$Y_2 = 7 - \frac{2}{2} = 6 \text{ in.}$$

Try W14 x 34 ($A = 10.0 \text{ in}^2$, $d = 14.0 \text{ in.}$)

$$\text{Assume } \Sigma Q_m = \frac{(100)(50)}{500} = 500 \text{ k}$$

$$a_{reqd} = \frac{500}{(0.85)(4)(102)} = 1.44 \text{ in.}$$

$$Y_2 = 7 - \frac{1.44}{2} = 6.28 \text{ in.}$$

$$Y_1 = 0$$

LFRD	ASD
$\phi_b M_b = 487 + \frac{(0.28)}{(0.50)}(506 - 487)$ $= 497.6 \text{ ft-k} > 427.7 \text{ ft-k} \text{ ok}$	$\frac{M_p}{\Omega_b} = \frac{324 + \frac{(0.28)}{(0.50)}(337 - 324)}{1.67}$ $= 331.3 \text{ ft-k} > 296.2 \text{ ft-k} \text{ ok}$

Going to the largest Y_1 so that $\phi_b M_p$ of about 427.7 ft-k is provided with $Y_2 = 6.28 \text{ in.}$

$$Y_1 = 0.228 \text{ in.}$$

$$\Sigma Q_m = 347 \text{ k}$$

$$a = \frac{347}{(0.85)(4)(102)} = 1.00 \text{ in.}$$

$$Y_2 = 7.00 - \frac{1.00}{2} = 6.50 \text{ in.}$$

453

EXCLUSIVE: Just in Edutruth only

PROB # 16-16 CONTO.

LRFD	ASD
$\phi_b M_p = 430 \text{ ft-k} > 427.7 \text{ ft-k}$	$\frac{M_p}{\Omega_b} = 286 \text{ ft-k} < 296.2 \text{ ft-k}$

Design of Studs

$$h_r = 3 \text{ in.}$$

$$\text{Assume } H_s = 5.0$$

Assume 1 stud in a rib @ beam intersection = N_r

$$w_r = 6 \text{ in.}$$

$$Q_n = 21.2 \text{ k}$$

$$\text{No of studs reqd} = \frac{(2)(347)}{21.2} = 32.75 \quad \boxed{\text{Say 33 Studs}}$$

For ASD it is necessary to go to $\psi_2 = 0.114 \text{ in.}$

$$\Sigma Q_n = 423 \text{ and } \frac{2 \times 423}{21.2} = 39.9 \quad \boxed{\text{Say 40 Studs}}$$

Compute LL Deflection

$$C_1 = 161$$

$$\text{Service } M_{LL} = \frac{(1.25)(34)^2}{8} = 180.6 \text{ ft-k}$$

$$I_x = \text{lower bound } I = 1090 \text{ in}^4$$

$$\Delta_{LL} = \frac{(180.6)(34)^2}{(161)(1090)} = 1.19 \text{ in.} > \left(\frac{1}{360}\right)(12 \times 34) = 1.13 \text{ in.} \quad \underline{\text{a little high}}$$

For ASD Δ will be less

Check Beam Shear

LRFD	ASD
$V_u = (17)(2.96) = 50.32 \text{ k}$ $< \phi_v V_n = 120 \text{ k} \quad \underline{\text{OK}}$	$V_a = (17)(2.05) = 34.85 \text{ k}$ $< \frac{V_n}{\Omega_v} = 79.78 \text{ k} \quad \underline{\text{OK}}$

ANSWRS.

USE W14X34
WITH 33 STUDS
LRFD

USE W14X34
WITH 40 STUDS
ASD

454

$\checkmark \phi < M_c$

EXCLUSIVE: Just in Edutruth only

PROB #16-17

Loads and Moments

LRFD	ASD
$w_u = (1.2)(0.8) + (1.6)(2.0) = 4.16 \text{ k/ft}$	$w_a = 0.8 + 2.0 = 2.8 \text{ k/ft}$
$M_u = \frac{(4.16)(34)^2}{8} = 601.1 \text{ ft-k}$	$M_a = \frac{(2.8)(34)^2}{8} = 404.6 \text{ ft-k}$

Effective flange width

$$b_e = (2) \left(\frac{1}{8} \right) (12 \times 34) = 102 \text{ in.} \leftarrow$$

$$b_e = 9 \text{ ft} = 108 \text{ in.}$$

(a) select W section

$$Y_{conc} = 4 + 3 = 7 \text{ in.}$$

$$\text{Assume } a = 2 \text{ in.}$$

$$Y_1 = 0$$

$$Y_2 = 7 - \frac{2}{2} = 6.00 \text{ in.}$$

$$\text{Try } W18 \times 40 \quad (A = 11.8 \text{ in.}^2, d = 17.9 \text{ in., } I_x = 612 \text{ in.}^4)$$

$$\phi Q_n = (11.8)(50) = 590 \text{ k}$$

$$a_{reqd} = \frac{5}{(0.85)(4)(102)} = 1.70 \text{ in.}$$

$$Y_1 = 0$$

$$Y_2 = 7 - \frac{1.70}{2} = 6.15 \text{ in.}$$

LRFD	ASD
$\phi_b M_p = 659 + \left(\frac{0.15}{0.50} \right) (681 - 659)$ $= 665.6 \text{ ft-k} > 601.1 \text{ ft-k}$	$\frac{M_p}{\Omega_b} = 439 + \left(\frac{0.15}{0.50} \right) (453 - 439)$ $= 443.2 \text{ ft-k} > 404.6 \text{ ft-k}$

Check deflection due to wet concrete plus wt of steel beam $= (9) \left(\frac{4}{12} \right) (10) + 40 = 370 \text{ lbs/ft.}$

$$M = \frac{(0.370)(34)^2}{8} = 53.46 \text{ ft-k}$$

$$\Delta = \frac{(53.46)(34)^2}{(161)(612)} = 0.627 \text{ in.} < 2 \frac{1}{2} \text{ in.} \quad \underline{\text{ok}}$$

455

EXCLUSIVE: Just in Edutruth only

PROB[#] 16-17 CONTD

Going in AISC Table 3-19 to the largest γ_1 so that a $\phi_b M_p$ of about 601.1 ft-k is provided with $\gamma_2 = 6.15$ in.

$$\gamma_1 = 0.131$$

$$\Sigma Q_m = 509 \text{ k}$$

$$a = \frac{509}{(0.85)(4)(0.2)} = 1.47 \text{ in.}$$

$$\gamma_2 = 7.00 - \frac{1.47}{2} = 6.265 \text{ in.}$$

LRFD	ASD
$\phi_b M_p = 623 + \left(\frac{0.265}{0.500}\right)(643 - 623) = 633.6 \text{ ft-k}$	$\frac{M_p}{\gamma_b} = 415 + \left(\frac{0.265}{0.500}\right)(428 - 415) = 421.7 \text{ ft-k}$

(b) Design of Studs

$Q_m = 17.2$ k each stud AISC Table 3-21 assuming 1 stud in a rib @ beam intersections

$$\text{No of studs reqd} = \frac{2 \times 509}{17.2} = 59.18 \text{ use}$$

60 total studs per beam

(c) Compute LL Deflection

$$M_{LL} = \frac{(2.00)(34)^2}{8} = 289 \text{ ft-k}$$

$$I_x = \text{lower bound } I_x \text{ from AISC Table 3-20}$$

$$= 1830 + \left(\frac{0.265}{0.500}\right)(1910 - 1830) = 1872 \text{ in.}^4$$

$$\Delta_{LL} = \frac{(289)(34)^2}{(161)(1872)} = 1.108 \text{ in.} < \left(\frac{1}{360}\right)(12 \times 34) = 1.13 \text{ in.} \underline{\underline{OK}}$$

(d) Check Beam Shear

LRFD	ASD
$w_u = (1.2)(0.8) + (1.6)(2.00) = 4.16 \text{ k/ft}$	$w_a = 0.8 + 2.00 = 2.80 \text{ k/ft}$
$V_u = (17)(4.16) = 70.72 \text{ k} < \phi_v V_{nx} = 146 \text{ k}$	$V_a = (17)(2.80) = 47.6 \text{ k} < \frac{V_n}{\gamma_b} = 97.7 \text{ k}$

ANSWERS,

USE W18X40 WITH 60 - $\frac{3}{4}$ STUDS
FOR LRFD and ASD

✓ JMC

EXCLUSIVE: Just in Edutruth only

PROB #16-19

Loads and moments

LRFD	ASD
$w_u = (1.2)(0.8) + (1.6)(1.5) = 3.36 \text{ k/ft}$	$w_a = 0.8 + 1.5 = 2.3 \text{ k/ft}$
$M_u = \frac{(3.36)(36)^2}{8} = 544.3 \text{ ft-k}$	$M_a = \frac{(2.3)(36)^2}{8} = 372.6 \text{ ft-k}$

Effective flange width

$$b_e = (2)(\frac{1}{8})(12 \times 36) = 108 \text{ in.}$$

$$b_e = 9 \text{ ft} = 108 \text{ in.}$$

(a) select W section

$$Y_{conc} = 4 + 3 = 7 \text{ in.}$$

$$\text{Assume } a = 2 \text{ in.}$$

$$Y_1 = 0$$

$$Y_2 = 7 - \frac{2}{2} = 6.0 \text{ in.}$$

$$\text{Try W18X35 } (A = 10.3 \text{ in.}^2, d = 17.70 \text{ in.}, I_x = 510 \text{ in.}^4)$$

checking deflection due to wet conc, beam and 25% LL

$$w_t = \left(\frac{4}{12}\right)(110)(9) + 35 + (25)(9) = 590 \text{ lbs/ft}$$

$$m = \frac{(0.590)(36)^2}{8} = 95.58 \text{ ft-lb}$$

$$C_1 = 161$$

$$\Delta = \frac{(95.58)(36)^2}{(161)(510)} = 1.5 \text{ in} < 2 \frac{1}{2} \text{ in. } \underline{\text{ok}}$$

$$\text{Assume } \Sigma Q_n = (10.3)(50) = 515 \text{ k}$$

$$a = \frac{515}{(0.85)(4)(108)} = 1.40 \text{ in.}$$

$$Y_1 = 0$$

$$Y_2 = 7 - \frac{1.40}{2} = 6.30 \text{ in.}$$

Going to largest Y_1 such that an M_u of about 544.3 ft-k is provided.

$$Y_1 = 0.106 \text{ in}$$

$$\Sigma P_n = 451 \text{ k}$$

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EXCLUSIVE: Just in Edutruth only

PROB#16-19 CONTD,

$$a = \frac{451}{(0.85)(4)(108)} = 1.23 \text{ in.}$$

$$Y_2 = 7 - \frac{1.23}{2} = 6.385 \text{ in.}$$

LRFD	ASD
$\phi_b M_p = 544 + \left(\frac{0.385}{0.500}\right)(561 - 544)$ $= 557.1 \text{ ft-k} > 544.3 \text{ ft-k}$	$\frac{M_p}{\Omega_b} = 362 + \left(\frac{0.385}{0.500}\right)(373 - 362)$ $= 370.5 \text{ ft-k} < 372.6 \text{ ft-k}$

(b) Design of Studs

LRFD	ASD
$\Sigma Q_n = 451 \text{ k}$ $Q_n \text{ for 1 stud} = 17.28 \text{ (AISC Table 3-21)}$ Total No of Studs Req'd $= \frac{(2)(451)}{17.2} = 52.44 \text{ SAY } 53$	Since $\frac{M_p}{\Omega_b}$ above too small use $Y_1 = 0$ and $\Sigma Q_n = 515 \text{ k}$ Total No of Studs Req'd $= \frac{(2)(515)}{17.2} = 59.88 \text{ SAY } 60$

(c) Service LL deflection after concrete hardens

$$\text{Service } M_{LL} = \frac{(1.50)(36)^2}{8} = 243 \text{ ft-k}$$

$$I_x = \text{lower bound } I \text{ from AISC table 3-20}$$

$$= 1570 + \left(\frac{0.385}{0.500}\right)(1640 - 1570) = 1624 \text{ in.}^4$$

$$\Delta_{LL} = \frac{(243)(36)^2}{(160)(1624)} = 1.20 \text{ in.} < \left(\frac{1}{360}\right)(12 \times 36) = 1.20 \text{ in. OK}$$

(d) Check beam shear

LRFD	ASD
$V_u = (18)(3.36) = 60.48 \text{ k}$ $< \phi_v V_n = 159 \text{ k} \text{ OK}$	$V_a = (18)(2.13) = 41.4 \text{ k}$ $< \frac{V_n}{\Omega_v} = 106 \text{ k} \text{ OK}$

ANSWERS,

USE W18X35 WITH 53 STUDS LRFD
USE W18X35 WITH 60 STUDS ASD

gmc

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EXCLUSIVE: Just in Edutruth only

PROB # 16-20 (1)

Loads applied before concrete hardens

$$\text{slab} = \left(\frac{4}{12}\right)(150)(6) = 300 \text{ lbs/ft}$$

$$\text{stem} = \frac{(12)(14)}{144}(150) = 175$$

$$W \text{ section} = 53$$

$$w_D = 528 \text{ lbs/ft}$$

$$M_D = \frac{(0.528)(30)^2}{8} = 59.4 \text{ ft-k}$$

Loads applied after concrete hardens

$$DL = (30)(6) = 180 \text{ lbs/ft}$$

$$LL = (120)(6) = 720$$

$$w_L = 900 \text{ lbs/ft}$$

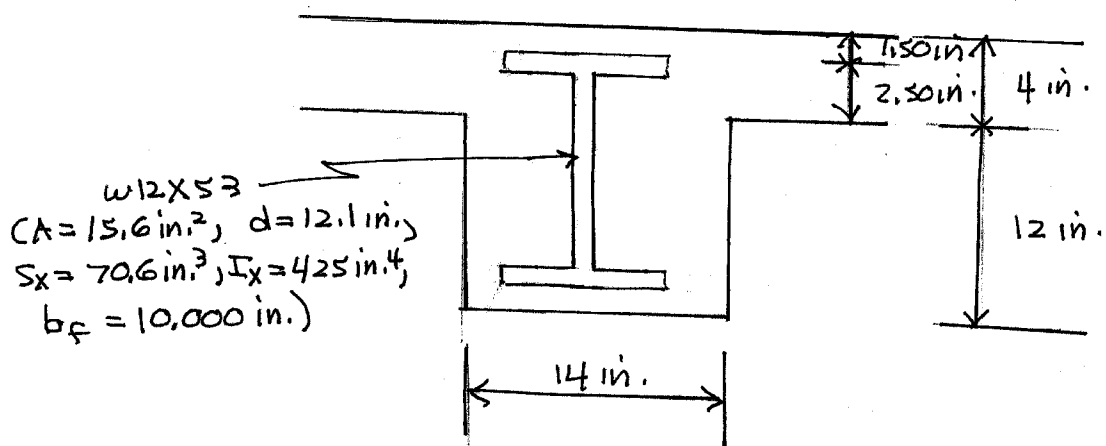
$$M_L = \frac{(0.900)(30)^2}{8} = 101.25 \text{ ft-k}$$

$$M_T = 59.4 + 101.25 = 160.65 \text{ ft-k}$$

Effective flange width

$$(a) 2 \times \frac{1}{8} \times 30 = 7.5 \text{ ft} = 90 \text{ in.}$$

$$(b) 6 \text{ ft} = 72 \text{ in.}$$



EXCLUSIVE: Just in Edutruth only

PROB# 16-20 CONTD,

Properties of section

$$A = 15.6 + \frac{(72)(4)}{9} = 15.6 + 32 = 47.6 \text{ in.}^2$$

$$\bar{y} = \frac{(15.6)(7.55) + (32)(2)}{47.6} = 3.82 \text{ in.}$$

$$I_x = \left(\frac{1}{3}\right)\left(\frac{72}{9}\right)(3.82)^3 + 425 + (15.6)(3.73)^2 = 790.7 \text{ in.}^4$$

Stress in steel before concrete hardens

$$f_s = \frac{(12)(59.4)}{70.6} = \boxed{10.10 \text{ ksi}}$$

Stresses in concrete and steel after concrete hardens

$$f_c = \frac{(12)(160.65)(3.82)}{(9)(790.7)} = \boxed{1.035 \text{ ksi}}$$

$$f_s = \frac{(12)(160.65)(9.78)}{790.7} = \boxed{23.84 \text{ ksi}}$$

$\checkmark \text{ } g < m \equiv$

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EXCLUSIVE: Just in Edutruth only

CHAPTER 17

PROB #17-1

Using a W14x90 ($A_s = 26.5 \text{ in}^2$, $I_{sx} = 999 \text{ in}^4$, $I_{sy} = 362 \text{ in}^4$, $r_y = 3.70 \text{ in.}$)

$$P_{s2} = \frac{A_{s2}}{A_g} = \frac{(4)(1.27)}{(22)(22)} = 0.0105 > 0.004 \quad \underline{\text{OK}} \quad (\text{Eq I2-1})$$

$$A_c = (22)(22) - 26.5 - (4)(1.27) = 452.42 \text{ in}^2$$

$$P_o = A_s F_y + A_{s2} F_{y2} + 0.85 A_c f'_c \quad (\text{Eq I2-4})$$

$$= (26.5)(50) + (4)(1.27)(60) + (0.85)(452.42)(5) = 3553 \text{ k}$$

$$C_1 = 0.1 + 2 \left(\frac{A_s}{A_c + A_s} \right) \leq 0.3 \quad (\text{Eq I2-7})$$

$$= 0.1 + (2) \left(\frac{26.5}{452.42 + 26.5} \right) = 0.211 < 0.3 \quad \underline{\text{OK}}$$

$$E_c = w_c^{1.5} \sqrt{f'_c} = 145^{1.5} \sqrt{5} = 3904 \text{ ksi}$$

$$I_c = \left(\frac{1}{12} \right) (22)(22)^3 - 362 = 19,159$$

$$EI_{eff} = E_s I_s + 0.5 E_s I_{s2} + C_1 E_c I_c \quad (\text{Eq I2-6})$$

$$= (29 \times 10^3)(999) + (0.5)(29 \times 10^3)(4)(1.27 \times 8.5^2) + (0.211)(3904)(19,159)$$

$$= 31,602 \times 10^6 \text{ ksi}$$

$$P_B = \frac{\pi^2 EI_{eff}}{(KL)^2} = \frac{(4)^2 (31,602 \times 10^6)}{(12 \times 14)^2} = 11,051 \text{ k} \quad (\text{Eq I2-5})$$

$$> 0.44 P_o = (0.44)(3553) = 1563 \text{ k}$$

$$\therefore P_m = P_o \left[0.658 \frac{P_o}{P_B} \right] = 3553 \left[0.658 \frac{3553}{11,051} \right] = 3106 \quad (\text{Eq I2-2})$$

LRFD $\phi_c = 0.75$	ASD $\Omega_c = 2.00$
$\phi_c P_m = (0.75)(3106) = 2329.5 \text{ k}$	$\frac{P_m}{\Omega_c} = \frac{3106}{2.00} = 1553 \text{ k}$

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✓ gcm

EXCLUSIVE: Just in Edutruth only

PROB#17-2

Using a W12X230 ($A_g = 67.7 \text{ in}^2$, $I_{sx} = 2420 \text{ in}^4$,
 $I_{sy} = 742 \text{ in}^4$, $r_y = 3.31 \text{ in}$)

$$P_{uz} = \frac{A_g}{A_g} = \frac{67.7}{(22)(24)} = 0.128 > 0.004 \quad \text{OK} \quad (\text{Eq I2-1})$$

$$A_c = (22)(24) - 67.7 - (4)(1.27) = 455.22 \text{ in}^2$$

$$P_o = A_g F_y + A_{uz} F_{yz} + 0.85 A_c F_c' \quad (\text{Eq I2-4})$$

$$= (67.7)(50) + (4)(1.27)(60) + (0.85)(455.22)(5) = 5614 \text{ k}$$

$$C_1 = 0.1 + 2 \left(\frac{A_g}{A_c + A_g} \right) = 0.1 + 2 \left(\frac{67.7}{455.22 + 67.7} \right) = 0.359 \leq 0.3 \quad (\text{Eq I2-7})$$

$$E_c = w_c^{1.5} \sqrt{F_c'} = 145^{1.5} \sqrt{5} = 3904 \text{ ksi}$$

$$I_c = \left(\frac{1}{12} \right) (24)(22)^3 - 742 = 20,554 \text{ in}^4 - 742 = 19,812 \text{ in}^4$$

$$EI_{eff} = E_s I_s + 0.5 E_s I_{sz} + C_1 E_c I_c \quad (\text{Eq. I2-6})$$

$$= (29 \times 10^3)(742) + (0.5)(29 \times 10^3)(4)(1.27 \times 8.5^2) + (0.3)(3904)(19,812) = 50.044 \times 10^6 \text{ ksi}$$

$$P_e = \frac{(\pi^2)(EI_{eff})}{(KL)^2} = \frac{(\pi^2)(50.044 \times 10^6)}{(12 \times 14)^2} = 17,500 \text{ k} \quad (\text{Eq I2-5})$$

$$P_e = 17,500 \text{ k} > 0.44 P_o = (0.44)(5614) = 2470 \text{ k}$$

∴ Use AISC Eq I2-2

$$P_m = P_o \left[0.658^{\frac{P_o}{P_e}} \right] \quad (\text{Eq I2-2})$$

$$= 5614 \left[0.658^{\left(\frac{5614}{17,500} \right)} \right] = 4909 \text{ k}$$

LRFD $\phi_c = 0.75$	ASD $\Omega_c = 2.00$
$\phi_c P_m = (0.75)(4909) = 3682 \text{ k}$	$\frac{P_m}{\Omega_c} = \frac{4909}{2.00} = 2454.5 \text{ k}$

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✓ JCMC

EXCLUSIVE: Just in Edutruth only

PROB#17-3

Using a 10X49 ($A_s = 14.4 \text{ in.}^2$, $I_{sx} = 272 \text{ in.}^4$, $I_{sy} = 93.4 \text{ in.}^4$, $r_y = 2.54 \text{ in.}$)

$$P_{n2} = \frac{A_{n2}}{A_g} = \frac{(4)(0.79)}{(18)(18)} = 0.00975 > 0.004 \quad \text{OK} \quad (\text{Eq I2-1})$$

$$A_c = (18)(18) - 14.4 - (4)(0.79) = 306.44 \text{ in.}^2$$

$$P_o = A_s F_y + A_{s2} F_{y2} + 0.85 A_c F'_c \quad (\text{Eq I2-4})$$

$$= (14.4)(50) + (4)(0.79)(60) + (0.85)(306.44)(6) = 2211.97 \text{ k}$$

$$C_1 = 0.1 + 2 \left(\frac{A_s}{A_c + A_s} \right) \leq 0.3 \quad (\text{Eq I2-7})$$

$$= 0.1 + 2 \left(\frac{14.4}{306.44 + 14.4} \right) = 0.190 < 0.3 \quad \text{OK}$$

$$E_c = w_c^{1.5} \sqrt{f'_c} = 145^{1.5} \sqrt{6} = 3904 \text{ ksi}$$

$$I_c = \left(\frac{1}{12} \right) (18)(18)^3 - 272 = 8476 \text{ in.}^4$$

$$EI_{eff} = E_s I_s + 0.5 E_c I_{s2} + C_1 E_c I_c \quad (\text{Eq I2-6})$$

$$= (29 \times 10^3)(93.4) + (0.5)(29 \times 10^3)(4)(0.79)(6.5^2) + (0.190)(3904)(8476) = 10.932 \times 10^6 \text{ ksi}$$

$$P_e = \frac{\pi^2 EI_{eff}}{(KL)^2} = \frac{(\pi^2)(10.932 \times 10^6)}{(12 \times 15)^2} \quad (\text{Eq I2-5})$$

$$= 3330 \text{ k} > 0.44 P_o = (0.44)(2211.97) = 973.3 \text{ k}$$

$$\therefore P_n = P_o \left[0.658 \frac{P_o}{P_e} \right] = 2211.97 \left[0.658 \frac{2211.97}{3330} \right] \quad (\text{Eq I2-2})$$

$$= 1675 \text{ k}$$

LRFD $\phi_c = 0.75$	ASD $\Omega_c = 2.00$
$\phi_c P_n = (0.75)(1675) = 1256 \text{ k}$	$\frac{P_n}{\Omega_c} = \frac{1675}{2.00} = 837.5 \text{ k}$

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✓ gcm

EXCLUSIVE: Just in Edutruth only

PROB# 17-4

Using an HSS 16x16 x $\frac{1}{2}$ ($A_g = 28.3 \text{ in}^2$, $I_x = 1130 \text{ in}^4$,
 $I_y = 1130 \text{ in}^4$, $t = 0.465 \text{ in}$.)

Cross sect A of HSS = $28.3 \text{ in}^2 \times (0.01)(16 \times 16) = 2.86 \text{ in}^2$ OK
 $\frac{b}{t} = 31.4 < 2.26 \sqrt{\frac{E_s}{F_y}} = 2.26 \sqrt{\frac{29 \times 10^3}{46}} = 56.7$ OK

$A_c = (16 \times 16) - 28.3 = 227.7 \text{ in}^2$

C_2 given = 0.85 in AISC Spec. I 2.2.6

$P_o = A_s F_y + A_{s2} F_{y2} + C_2 A_c F_c$ (Eq I 2-13)
 $= (28.3)(46) + 0 + (0.85)(227.7)(4) = 2076 \text{ k}$

$C_3 = 0.6 + 2 \left(\frac{A_s}{A_c + A_s} \right) \leq 0.9$ (Eq I 2-15)
 $= 0.6 + (2) \left(\frac{28.3}{227.7 + 28.3} \right) = 0.821 < 0.9$ OK

$E_c = w_c^{1.5} \sqrt{4} = (145)^{1.5} \sqrt{4} = 3492 \text{ ksi}$

$I_c = \left(\frac{1}{12} \right) (16)(16)^3 - 1130 = 4331$

$E I_{eff} = E_s I_s + E_s I_{s1} + C_3 E_c I_c$ (Eq I 2-14)
 $= (29 \times 10^3)(1130) + 0 + (0.821)(3492)(4331) = 45.187 \times 10^6 \text{ ksi}$

$P_e = \frac{\pi^2 E I_{eff}}{(KL)^2}$ (Eq I 2-5)
 $= \frac{(\pi^2)(45.187 \times 10^6)}{[12)(14)]^2} = 15,801 \text{ k}$

$P_e = 15,801 > 0.44 P_o = (0.44)(2076) = 913.4 \text{ k}$

$\therefore P_m = P_o \left[0.658 \frac{P_o}{P_e} \right]$ (Eq I 2-2)
 $= 2076 \left[0.658 \frac{2076}{15,801} \right] = 1965 \text{ k}$

LRFD $\phi_c = 0.75$	ASD $\Omega_c = 2.00$
$\phi_c P_m = (0.75)(1965) = 1474 \text{ k}$	$\frac{P_m}{\Omega_c} = \frac{1965}{2.00} = 982.5 \text{ k}$

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VJC

EXCLUSIVE: Just in Edutruth only

PROB* 17-5

Using an HSS 14x10x $\frac{1}{2}$ ($A_g = 20.9 \text{ in.}^2$, $I_x = 573 \text{ in.}^4$,
 $I_y = 341 \text{ in.}^4$, $t = 0.465 \text{ in.}$)

Cross Sect A of HSS = $20.9 > (0.01)(14)(10) = 1.4 \text{ in.}^2$ OK

$$\frac{b}{t} = 27.1 < 2.26 \sqrt{\frac{E_s}{F_y}} = 2.26 \sqrt{\frac{29 \times 10^3}{50}} = 54.43$$

$$A_c = (14)(10) - 20.9 = 119.1 \text{ in.}^2$$

C_2 given = 0.85 in AISC Spec. I2.2.6

$$P_o = A_s F_y + A_{s2} F_{y2} + C_2 A_c F_c' \quad (\text{Eq. I 2-13})$$

$$= (20.9)(46) + 0 + (0.85)(119.1)(4) = 1366.3 \text{ k}$$

$$C_3 = 0.6 + 2 \left(\frac{A_s}{A_c + A_s} \right) \leq 0.9 \quad (\text{Eq. I 2-15})$$

$$= 0.6 + 2 \left(\frac{20.9}{119.1 + 20.9} \right) = 0.899 < 0.9 \quad \text{OK}$$

$$E_c = w_c^{1.5} \sqrt{f_c} = (145)^{1.5} \sqrt{4} = 3492 \text{ ksi}$$

$$I_c = \left(\frac{1}{12} \right) (14) (10)^3 - 341 = 826 \text{ in.}^4$$

$$E I_{eff} = E_s I_s + E_s I_{s2} + C_3 E_c I_c \quad (\text{Eq. I 2-14})$$

$$= (29 \times 10^3)(341) + 0 + (0.899)(3492)(826) = 12.482 \times 10^6 \text{ ksi}$$

$$P_e = \frac{\pi^2 E I_{eff}}{(KL)^2} \quad (\text{Eq. I 2-5})$$

$$= \frac{(\pi^2)(12.482 \times 10^6)}{(12 \times 12)^2} = 5941 \text{ k}$$

$$P_e = 5941 > 0.44 P_o = (0.44)(1366.3) = 601.2 \text{ k}$$

$$\therefore P_m = P_o \left[0.658 \sqrt{\frac{P_o}{P_e}} \right] \quad (\text{Eq. I 2-2})$$

$$= 1366.3 \left[0.658 \sqrt{\frac{1366.3}{5941}} \right] = 1241 \text{ k}$$

LRFD $\phi_c = 0.75$	ASD $\Omega_c = 2.00$
$\phi_c P_m = (0.75)(1241) = 930.7 \text{ k}$	$\frac{P_m}{\Omega_c} = \frac{1241}{2.00} = 620.5 \text{ k}$

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✓ JC

EXCLUSIVE: Just in Edutruth only

PROB# 17-6

Using a Pipe 12 Std ($A = 13.6 \text{ in.}^2$, $\frac{D}{t} = 36.5$,
 $I = 262 \text{ in.}^4$, $t = 0.349 \text{ in.}$)

$$\frac{D}{t} = 36.5 < 0.15 \frac{E}{F_y} = (0.15) \left(\frac{29,000}{35} \right) = 124.3 \quad \text{OK}$$

$C_2 = 0.95$ as given in AISC I 2.26

$$A_c = \frac{(\pi)(12.8)^2}{4} - 13.6 = 115.1 \text{ in.}^2$$

$$P_0 = A_s F_y + A_{s2} F_{y2} + C_2 A_c F_c \quad (\text{Eq I 2-13})$$

$$= (13.6)(35) + 0 + (0.95)(115.1)(5) = 1022.7 \text{ k}$$

$$C_3 = 0.6 + 2 \left(\frac{A_s}{A_c + A_s} \right) \quad (\text{Eq I 2-15})$$

$$= 0.6 + 2 \left(\frac{13.6}{115.1 + 13.6} \right) = 0.811 < 0.9 \quad \text{OK}$$

$$E_c = w_c^{1.5} \sqrt{5} = 3904 \text{ ksi}$$

$$I_c = \frac{(\pi)(12)^4}{64} - 262 = 755.88 \text{ in.}^4$$

$$EI_{eff} = E_s I_s + E_s I_{s2} + C_3 E_c I_c \quad (\text{Eq I 2-14})$$

$$= (29 \times 10^3)(262) + 0 + (0.811)(3904)(755.88)$$

$$= 9.991 \times 10^6 \text{ ksi}$$

$$P_e = \frac{(\pi^2)(EI_{eff})}{(KL)^2} \quad (\text{Eq I 2-5})$$

$$= \frac{(\pi^2)(9.991 \times 10^6)}{(12 \times 15)^2} = 3043.5 \text{ k}$$

$$P_e = 3043.5 > 0.44 P_0 = (0.44)(1022.7) = 450 \text{ k}$$

$$\phi_c P_n = P_0 \left[0.658^{\frac{P_0}{P_e}} \right] = 1022.7 \left[0.658^{\frac{1022.7}{3043.5}} \right] = 888.5 \text{ k}$$

LRFD $\phi_c = 0.75$	ASD $\Omega_c = 2.00$
$\phi_c P_n = (0.75)(888.5) = 666.4 \text{ k}$	$\frac{P_n}{\Omega_c} = \frac{888.5}{2.00} = 444.2 \text{ k}$

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✓ gcm

EXCLUSIVE: Just in Edutruth only

PROB# 17-7

(a) From AISC Table 4-15 for HSS 16x16x $\frac{1}{2}$
with $F_c' = 4 \text{ ksi}$ and $F_y = 46 \text{ ksi}$, $KL = 14 \text{ ft}$

LRFD	ASD
$\phi_c P_n = 1470 \text{ k}$	$\frac{P_n}{\Omega_c} = 982 \text{ k}$

(b) From AISC Table 4-13 for HSS 14x10x $\frac{1}{2}$ with
 $F_c' = 4 \text{ ksi}$, $F_y = 46 \text{ ksi}$ and $KL = 12 \text{ ft}$

LRFD	ASD
$\phi_c P_n = 928 \text{ k}$	$\frac{P_n}{\Omega_c} = 619 \text{ k}$

(c) From AISC Table 4-20 for Pipe 12 Std
with $F_c' = 5 \text{ ksi}$, $F_y = 35 \text{ ksi}$ and $KL = 15 \text{ ft}$

LRFD	ASD
$\phi_c P_n = 671 \text{ k}$	$\frac{P_n}{\Omega_c} = 446 \text{ k}$

✓ JCM

469

EXCLUSIVE: Just in Edutruth only

PROB # 17-8

LRFD	ASD
$P_u = (1.2 \times 70) + (1.6 \times 120) = 276k$	$P_a = 70 + 120 = 190k$

Select HSS 9.625 x 0.312 concrete filled round section (steel wt 31.1 lbs/ft) from AISC Table 4-17

LRFD	ASD
$\phi_c P_n = 288k > 276k \quad \underline{\text{ok}}$	$\frac{P_n}{\Omega_c} = 192k > 190k \quad \underline{\text{ok}}$

✓ gmc

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EXCLUSIVE: Just in Edutruth only

CHAPTER 18

PROB #18-1

Assume beam $w_t = 160 \text{ lbs/ft}$

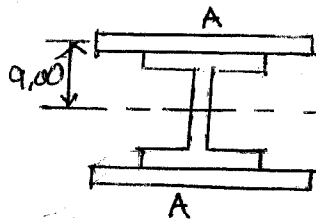
LRFD	ASD
$w_u = (1.2)(3.16) + (1.6)(3) = 8.592 \text{ k/ft}$	$w_a = 3.16 + 3 = 6.16 \text{ k/ft}$
$M_u = \frac{(8.592)(36)^2}{8} = 1391.9 \text{ ft-k}$	$M_a = \frac{(6.16)(36)^2}{8} = 997.9 \text{ ft-k}$

$$Z_{\text{Reqd}} = \frac{(12)(1391.9)}{(0.9)(36)} = 515.5 \text{ in.}^3$$

Several W16 sections may be used

Try W16x100 ($d = 17.0 \text{ in.}$, $b_f = 10.4 \text{ in.}$, $Z_x = 198 \text{ in.}^3$) with
1 cover plate each flange

Assume 1-in thick plates.



$$198 + (2A)(9.00) = 515.5 \text{ in.}^3$$

$$A = 17.64 \text{ in.}^2 \quad \text{Try } 1 \times 18 \text{ PL each flange}$$

$$Z_{\text{furnished}} = 198 + (2)(18)(9) = 522 \text{ in.}^3$$

$$M_m = \frac{F_y Z}{12} = \frac{(36)(522)}{12} = 1566 \text{ ft-k}$$

LRFD $\phi_b = 0.90$	ASD $\Omega_b = 1.67$
$\phi_b M_m = (0.90)(1566) = 1409.4 \text{ ft-k}$ $> 1391.9 \text{ ft-k}$ <u>OK</u>	$\frac{M_m}{\Omega_b} = \frac{1566}{1.67} = 937.7 \text{ ft-k}$ $< 997.9 \text{ ft-k}$ <u>N.G.</u>

ONE SET	W16x100 with PL1x18 each flange	LRFD
OF ANSWERS	W16x100 with PL1x20 each flange	ASD

✓ JCM

EXCLUSIVE: Just in Edutruth only

PROB #18-2

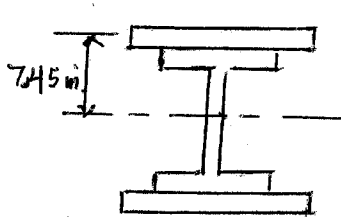
Assume beam wt = 150 lbs/ft

LRFD	ASD
$w_u = (1.2)(4.15) + (1.6)(6) = 14.58 \text{ k/ft}$	$w_a = 4.15 + 6 = 10.15 \text{ k/ft}$
$M_u = \frac{(14.58)(24)^2}{8} = 1049.8 \text{ ft-k}$	$M_a = \frac{(10.15)(24)^2}{8} = 730.8 \text{ ft-k}$

$$Z_{\text{reqd}} = \frac{(12)(1049.8)}{(0.9)(50)} = 279.9 \text{ in.}^3$$

Using a W14X53 ($d = 13.9 \text{ in.}$, $b_f = 8.06 \text{ in.}$, $Z_x = 87.1 \text{ in.}^3$)
with 1 cover plate each flange

Assume 1-in thick PLs



$$279.9 = 87.1 + (A)(7.45)(2)$$

$$A = 12.94 \text{ in.}^2 \quad \text{Try 1 PL } 1 \times 13 \text{ each flange}$$

$$Z_{\text{furnished}} = 87.1 + (2)(13)(7.45) = 280.8 \text{ in.}^3$$

$$M_m = \frac{F_y Z}{12} = \frac{(50)(280.8)}{12} = 1170 \text{ ft-k}$$

LRFD $\phi_b = 0.90$	ASD $\Omega_b = 1.67$
$\phi_b M_m = (0.90)(1170) = 1053 \text{ ft-k}$ $> 1049.8 \text{ ft-k} \quad \text{OK}$	$\frac{M_m}{\Omega_b} = \frac{1170}{1.67} = 700.6 \text{ ft-k}$ $< 730.8 \text{ ft-k} \quad \text{N.G.}$

ONE SET	W14X53 WITH PL1X13 each flange	LRFD
OF ANSWERS,	W14X53 WITH PL1X4 each flange	ASD

✓ JCM

EXCLUSIVE: Just in Edutruth only

PROB# 18-3

Assume girder wt = 110 lbs/ft

LRFD	ASD
$w_u = (1.2)(1.10) + (1.6)(1.8) = 4.212 \text{ k/ft}$	$w_a = 1.10 + 1.8 = 2.910 \text{ k/ft}$
$M_u = \frac{(4.212)(30)^2}{8} = 1316.25 \text{ ft-k}$	$M_a = \frac{(2.910)(30)^2}{8} = 909.4 \text{ ft-k}$
$V_u = (25)(4.212) = 105.3 \text{ k}$	$V_a = (25)(2.91) = 72.75 \text{ k}$

Design for a compact web and flange

$$Z_{\text{Reqd}} = \frac{(12)(1316.25)}{(0.9)(36)} = 487.5 \text{ in}^3$$

Web size reqd.

$$\text{For web to be compact } \frac{h}{t_w} \text{ must be } \leq 3.76 \sqrt{\frac{E}{F_y}}$$

$$= 3.76 \sqrt{\frac{29 \times 10^3}{36}} = 106.7$$

$$\text{Assume } h = 48 - 2 = 46 \text{ in.}$$

$$\text{Min. } t_w = \frac{46}{106.7} = 0.43 \text{ in. say } \frac{7}{16} \text{ in.}$$

$$\text{Try } \frac{7}{16} \times 46 \text{ web } (A_w = 20.125 \text{ in}^2)$$

$$\frac{h}{t_w} = \frac{46}{\frac{7}{16}} = 105.1$$

According to AISC Section G2.2 transverse stiffeners are not needed if $\frac{h}{t_w} \leq 2.46 \sqrt{\frac{E}{F_y}} = 2.46 \sqrt{\frac{29 \times 10^3}{36}} = 69.82 < 105.1$, or if reqd shear strength is \leq the available shear strength provided as follows with $F_v = 50$.

$$\frac{h}{t_w} = 105.1 > 1.37 \sqrt{\frac{(5)(29 \times 10^3)}{36}} = 86.95$$

$$C_v = \frac{(1.51)(29 \times 10^3)(5)}{(105.1)^2(36)} = 0.5506 \quad (\text{Eq. G2-5})$$

$$V_n = (0.6)(36)\left(\frac{7}{16} \times 46\right)(0.5506) = 239.3 \text{ k} \quad (\text{Eq. G2-1})$$

LRFD ϕ	ASD $\Omega_v = 1.67$
$\phi V_n = (0.90)(239.3) = 215.4 \text{ k} > 105.3 \text{ k}$ No stiffeners needed	$\frac{V_n}{\Omega_v} = \frac{239.3}{1.67} = 142.3 \text{ k} > 72.75 \text{ k} \quad \underline{\text{OK}}$

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EXCLUSIVE: Just in Edutruth only

PROB#18-3 CONTD.

Flange area

$$A_p \text{ reqd.} = \frac{M_u}{\phi_b F_y (h + t_f)} - \frac{t_w h^2}{4(h + t_f)}$$

Assume $\frac{5}{8}$ -in plates

$$A_p = \frac{(2)(1316.25)}{(0.9)(36)(46 + 0.625)} - \frac{(\frac{7}{16})(46)^2}{(4)(46 + 0.625)} = 5.49 \text{ in.}^2$$

$$\text{Try 1 PL } \frac{5.49}{0.625} = 8.64 \text{ in. wide say } 9 \text{ in.}$$

Are the flanges compact by AISC Table B4.1 (Case 2)

$$\frac{b_f}{2t_f} = \frac{9}{(2)(\frac{5}{8})} = 7.2 < 0.38 \sqrt{\frac{29 \times 10^3}{36}} = 10.79 \quad \text{Yes}$$

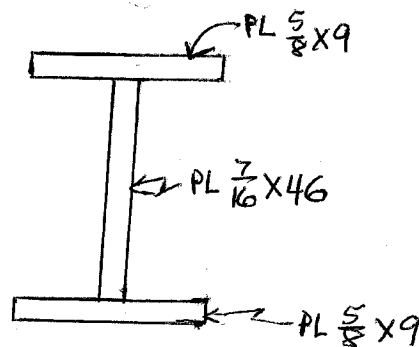
Check Z of section

$$Z = (2)(\frac{46}{2})(\frac{7}{16})(\frac{46}{4}) + (2)(\frac{5}{8} \times 9)(23.31) = 493.68 \text{ in.}^3 > 487.5 \text{ in.}^3$$

Check girder weight

$$wt = \frac{(\frac{7}{16} \times 46) + (2)(\frac{5}{8} \times 9)}{144} (490) = 106.81 \text{ lbs/ft} < 110 \text{ lbs/ft} \quad \text{OK}$$

USE $\frac{7}{16} \times 46$ web with 1 PL $\frac{5}{8} \times 9$ each flange



✓ JCMC

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EXCLUSIVE: Just in Edutruth only

PROB# 18-4

Maximum shear and moment

Assume beam wt = 130 lbs/ft

LRFD	ASD
$w_u = (1.2)(1.13) + (1.6)(1.8) = 4.236 \text{ k/ft}$	$w_a = 1.13 + 1.8 = 2.93 \text{ k/ft}$
$M_u = \frac{(4.236)(60)^2}{8} = 1906 \text{ ft-k}$	$M_a = \frac{(2.93)(60)^2}{8} = 1318.5 \text{ ft-k}$
$V_u = (30)(4.236) = 127.1 \text{ k}$	$V_a = (30)(2.93) = 87.9 \text{ k}$

Design for a compact web and flange

$$Z_{\text{Reqd}} = \frac{M_u}{\phi_b F_y} = \frac{(12)(1906)}{(0.9)(50)} = 508 \text{ in.}^3$$

web size required

For web to be compact $\frac{h}{t_w}$ must be $\leq 3.76 \sqrt{\frac{E}{F_y}}$

$$= 3.76 \sqrt{\frac{29 \times 10^3}{50}} = 90.55$$

Assume $h = 48 - 2 = 46 \text{ in.}$

Min. $t_w = \frac{46}{90.55} = 0.508 \text{ in.}$ Say $\frac{5}{8} \text{ in.}$

Try $\frac{5}{8} \times 46 \text{ web } (A_w = 28.75 \text{ in.}^2)$

$$\frac{h}{t_w} = \frac{46}{\frac{5}{8}} = 73.6 < 90.55$$

Are transverse stiffeners needed?

According to AISC Specification ^{63.2} transverse stiffeners are not needed if $\frac{h}{t_w} \leq 2.46 \sqrt{\frac{E}{F_y}}$

$$= 2.46 \sqrt{\frac{29,000}{50}} = 59.24 < 73.6$$

or if required shear strength $V_u = 127.1 \text{ k}$ is \leq the available shear provided as follows

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EXCLUSIVE: Just in Edutruth only

PROB#18-4 CONTD.

with $k_v = 5$

$$\frac{h}{t_w} = 73.6 \approx 1.37 \sqrt{\frac{5 \times 29 \times 10^3}{50}} = 73.77$$

$$C_u = \frac{(1.51)(29 \times 10^3)(5)}{(73.6)^2(50)} = 0.808 \quad (\text{Eq G2-5})$$

$$V_m = (0.6)(50) \left(\frac{5}{8} \times 46 \right) (0.808) = 696.9 \text{ k} > 127.1 \text{ k} \quad \text{OK}$$

LRFD	ASD
$\phi V_m = (0.9)(696.9) = 627.2 \text{ k} > 127.1 \text{ k}$ \therefore No transv. stiff reqd	$\frac{V_m}{\Omega_v} = \frac{696.9}{1.67} = 417.3 \text{ k} > 87.9 \text{ k} \quad \text{OK}$ \therefore No trans. stiff reqd.

Flange area

Assume 1-in. plates

$$A_p \text{ reqd} = \frac{m_u}{\phi_b F_y (h + t_f)} - \frac{\frac{t_w h^2}{4(h + t_f)}}{(0.9)(50)(46 + 1)} - \frac{\left(\frac{5}{8}\right)(46)^2}{(4)(46 + 1)} = 3.34 \text{ in.}^2$$

Try 1x4 Plate

Are flanges compact?

$$\frac{b_f}{2t_f} = \frac{4}{2} = 2 < 0.38 \sqrt{\frac{29 \times 10^3}{50}} = 9.15 \quad \text{Yes}$$

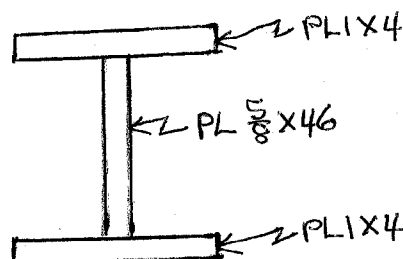
Check Z of section selected

$$Z = (2)(1 \times 4)(23.5) + (2)(23) \left(\frac{5}{8} \right) \left(\frac{23}{2} \right) = 518.6 \text{ in.}^3 > 508 \text{ in.}^3 \quad \text{OK}$$

Check weight of section

$$W_t = \frac{\left(\frac{5}{8}\right)(46) + (2)(1 \times 4)}{144} (490) = 125 \text{ lbs/ft} < 130 \text{ lbs/ft} \quad \text{OK}$$

USE $\frac{5}{8} \times 46$ web with 1 PL1x4 each flange



✓ g c m c

EXCLUSIVE: Just in Edutruth only

PROB #18-5(1)

Maximum moment and shear

Assume beam $w_t = 250 \text{ lbs/ft}$

L-RFD	ASD
$w_u = (1.2)(2.25) + (1.6)(4.5) = 9.9 \text{ k/ft}$	$w_a = 2.25 + 4.5 = 6.75 \text{ k/ft}$
$R_u = \left(\frac{60}{2}\right)(9.9) = 297 \text{ k}$	$R_a = \left(\frac{60}{2}\right)(6.75) = 202.5 \text{ k}$
$M_u = \frac{(9.9)(60)^2}{8} = 4455 \text{ ft-k}$	$M_a = \frac{(6.75)(60)^2}{8} = 3037.5 \text{ ft-k}$

Design for compact web and flanges

$$Z_{\text{Reqd}} = \frac{(1.2)(4455)}{(0.9)(36)} = 1650 \text{ in}^3$$

Assume girder depth = $\left(\frac{1}{10}\right)(60) = 6 \text{ ft} = 72 \text{ in.}$

For web to be compact by AISC Table B4.1

$$\frac{h}{t_w} \text{ must be } \leq 3.76 \sqrt{\frac{E}{F_y}} \quad (\text{Case 9 AISC Table B4.1})$$
$$= 3.76 \sqrt{\frac{29 \times 10^3}{36}} = 106.7$$

Assume h of web = $72 - 2 = 70 \text{ in.}$

$$\text{Min } t_w = \frac{70}{106.7} = 0.656 \text{ in.} \quad \text{Say } \underline{\underline{\frac{11}{16} \text{ in.}}}$$

Try $\frac{11}{16} \times 70$ web

$$\frac{h}{t_w} = \frac{70}{\frac{11}{16}} = 101.8$$

Since 101.8 is $> 2.46 \sqrt{\frac{E}{F_y}} = 2.46 \sqrt{\frac{29,000}{36}} = 69.82$
transverse stiffeners may be required by
AISC Specification G2.2.

EXCLUSIVE: Just in Edutruth only

PROB #18-5 (2)

But the same specification states that stiffeners are not required if the shear strength for the web is \leq than its available shear strength as required by AISC Specification A2.1 using $k_v = 5.0$.

$$\frac{h}{t_w} = 101.8 > 1.37 \sqrt{\frac{k_v E}{F_y}} = 1.37 \sqrt{\frac{(5)(29,000)}{36}} = 86.95$$

$$\therefore C_v = \frac{1.5 E k_v}{\left(\frac{h}{t_w}\right)^2 F_y} = \frac{(1.5)(29 \times 10^3)(5)}{(101.8)^2 (36)} = 0.583$$

$$V_n = 0.6 F_y A_w C_v = (0.6)(36) \left(70 \times \frac{11}{16}\right) (0.583) = 606 \text{ k}$$

LRFD $\phi_v = 0.9$	ASD $\Omega_v = 1.67$
$\phi_v V_n = (0.9)(606) = 545.4 \text{ k}$ $> 297 \text{ k}$	$\frac{V_n}{\Omega_v} = \frac{606}{1.67} = 362.9 \text{ k}$ $> 202.5 \text{ k}$
\therefore stiffeners are not required.	\therefore stiffeners are not required.

Trial flange size

Assume 1-in. plates

$$A_f = \frac{M_u}{\phi_b F_y (h + t_f)} - \frac{t_w h^2}{4(h + t_f)}$$

$$= \frac{(12)(445)}{(0.9)(36)(70+1)} - \frac{\left(\frac{11}{16}\right)(70)^2}{4(70+1)} = 11.38 \text{ in}^2$$

Try 1x12 plate each flange. Are they compact by AISC Table B4.1 (Case 2)

$$\frac{b_f}{2t_f} = \frac{12}{2(1)} = 6.00 < 0.38 \sqrt{\frac{E}{F_y}}$$

$$= 0.38 \sqrt{\frac{29,000}{36}} = 10.79 \quad \underline{\text{Yes}}$$

EXCLUSIVE: Just in Edutruth only

PROB # 18-5 (3)

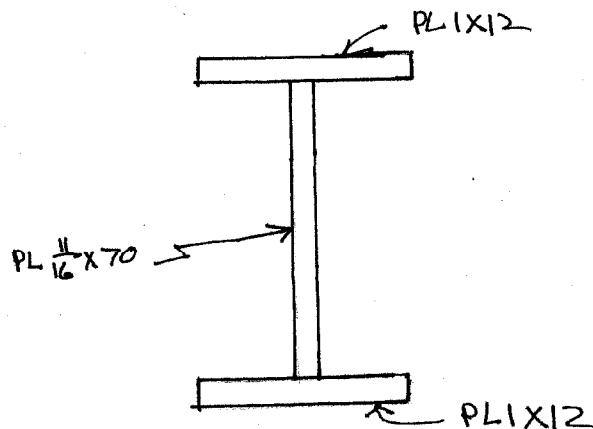
Check Z of section

$$Z = (2) \left(\frac{70}{2} \right) \left(\frac{11}{16} \right) \left(\frac{70}{4} \right) + (2) (1 \times 12) \left(\frac{70}{2} + \frac{1}{2} \right) \\ = 1694.2 \text{ in.}^3 > 1650 \text{ in.}^3 \quad \underline{\text{ok}}$$

Check girder wt

$$wt = \frac{\left(\frac{11}{16} \right) (70) + (2) (1 \times 12)}{144} (490) = 245.4 \text{ lbs/ft} \\ < 250 \text{ lbs/ft assumed}$$

USE $\frac{11}{16} \times 70$ web with 1 x 12 PL EACH FLANGE



✓ gcm